Appendix 2

Canadian and U.S. Land: Its Ownership, Cover, and Uses

Canada and the United States together cover 19.8 million km^2, have economies worth US$19.1 trillion, and have a combined population of 357 million people. In area, Canada is the second-largest country, after Russia, and the United States the third-largest. The United States is the world's largest economy and Canada ranks 11th, but together, their economies are larger than the European Union. Yet in population, the two countries have just 6 percent of the globe's people—far behind China and India, which together have 36 percent.

The lands of Canada and the United States grow valuable agricultural crops and wood products. The two countries are among the world's leaders in grain production and wood products (UN FAO 2013). The United States is the world's leading producer of maize, sorghum, and soybeans, and the third-largest producer of wheat and cotton. Canada is the world's largest producer of rapeseed oil (canola), accounting for 20 percent of the global crop, the third-largest producer of barley, and the seventh-largest producer of wheat. The United States is the world's largest producer of lumber and dissolving wood pulp; Canada is third in both categories. The United States is the second-largest producer of paper and paperboard and the third-largest producer of wood panel products. Cattle herds total 94.3 million animals in the two countries, and beef production contributes nearly US$84 billion to the two countries' economies. Therefore, the health and productivity of croplands, rangelands, and forests are vitally important to both countries, and trends affecting these lands are important components of any environmental outlook.

This appendix on landownership, land cover, and land use draws from Guldin (2015).

Landownership patterns

Landownership differs substantially between the United States and Canada (Figure 1). Although total land area between the two countries is comparable—2.25 billion acres for Canada (9.1 million km^2) versus 2.26 billion acres (9.15 million km^2) for the United States—about 90 percent of Canada is Crown land, split almost evenly between federal and provincial control. The majority of the federally controlled land in Canada is held in trust for First Nations. In the United States, 59 percent of the land is in private ownership, 32 percent is federal land, and 3 percent is held in trust for Native American tribal governments.

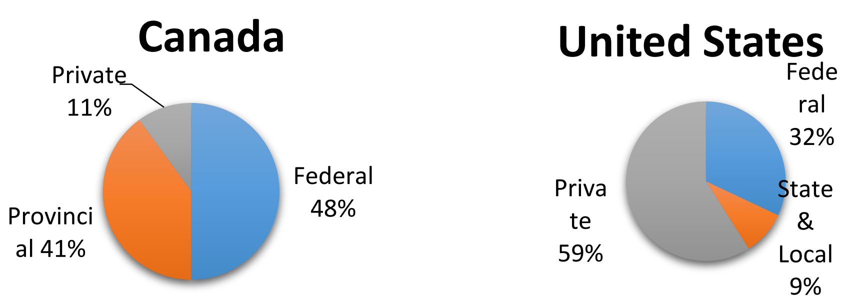

Figure 1. Landownership distribution, 2015

These differences in ownership affect the policies, regulations, and incentives that influence how land and its resources are managed in the two countries. In the United States, individual landowners (11 million private forestland owners and more than 2 million farmers) and their interests are important. There are also 50 state governments with diverse interests, capacities, and regulatory authorities. In Canada, the 13 provincial governments play dominant roles, but there are 294,000 farm operators whose interests are at stake too.

Canada

Understanding landownership patterns in Canada begins with understanding Crown land. About 89 percent of Canada's land area (888.6 million ha) is Crown land, divided between the federal (41 percent) and provincial (48 percent) governments. Most federal Crown land is in the territories (Northwest Territories, Nunavut, and Yukon) and is administered by Aboriginal Affairs and Northern Development Canada. Only 4 percent of land in the provinces is federally controlled, largely in the form of national parks, First Nations reserves, or Canadian Armed Forces bases. Provincial Crown land may be held as provincial parks or wilderness or leased to extractive industries.

Crown land provides the country and the provinces with the majority of their revenues from natural resources, largely but not exclusively provincial. This land is rented for logging and mineral exploration rights; revenues flow to the relevant government and are a major income stream. Crown land may also be rented by individuals for building homes and cottages, which complicates understanding the "ownership" patterns in Canada.

The remaining 11 percent of Canada's land area is privately owned, of which two-thirds is agricultural land, owned or rented by farmers (7.3 percent of total land area). The other third of private land is composed of a small amount of private forest land and developed areas.

United States

Landownership in the United States differs strongly between the eastern and western states. In the East, private ownership dominates. The percentage of private land in southern and northeastern states is typically in the mid-80s, and even the mid-90s in the southern Great Plains. In contrast, public ownership—nearly all federal—dominates in the West: 96 percent of Alaska is federal land, 88 percent of Nevada, 75 percent of Utah, 70 percent of Idaho, 60 percent of Oregon, and more than 50 percent of California, Wyoming, and Arizona. These differences in public versus private ownership play out in many ways. State and local governments are responsible for setting land management policies and enforcing regulations for private lands. Federal land management policies are aimed mostly at federal lands. But there are many types of policies and regulations where federal laws, policies, and regulations do affect private landowners—either directly (e.g., federal tax breaks for certain types of agricultural and forestry activities) or through state or local government regulatory activities. But in general, federal land management policies are often seen as more important by westerners because of the high percentage of federal land ownership there.

Hickman (2007) has summarized recent changes in private ownership in considerable detail. Until the mid-1980s, most forest products companies were vertically integrated, owning land to grow the wood that was the raw material for their manufacture of solid wood, panel, and paper products. But several changes in tax laws and regulations and a desire to show greater returns to stockholders led many companies to sell all or a large part of their forestland or to restructure to legally separate ownership and control of forestland from their manufacturing facilities. Where land was sold, much of it is now held by timber investment management organizations (TIMOs). TIMOs buy, manage, and sell forestland and timber on behalf of various institutional investors, including insurance companies, pension funds, endowments, and foundations. Where restructuring occurred, the land and timber are now held by real estate investment trusts (REITs). REITs buy, manage, and sell real estate or real estate–related assets, such as mortgages, on behalf of various private investors.

The magnitude of the ownership shift has been substantial. In 1985, TIMOs and REITs held less than $1 billion of assets. But by 2005, holdings exceeded $25 billion, with approximately $15.0 billion having been invested by TIMOs and $10.2 billion by publicly traded REITs. In 1980, vertically integrated forest products companies owned 58 million acres in the United States, but by 2005, they owned only 21 million acres—a drop of 60 percent. Of the roughly 27 million acres of forestland sold, an estimated 15 million acres was acquired by

TIMOs, 2 million acres by privately held (family-owned) forest products companies, and the remaining 10 million acres by conservation groups (e.g., The Nature Conservancy, the Conservation Fund), other private owners, and government agencies. Over that same period, TIMOs and REITS grew from nothing to more than 25 million acres. The holdings of the TIMOs and REITs are spread across all commercial forest regions, but the biggest concentrations are in pine plantations in the Southeast, conifer plantations in the Pacific Northwest (west of the Cascades), and mixed softwood and hardwood stands in the Northeast.

Managing forestland has always been a long-term enterprise. One of the unknowns that created uncertainty during the past three decades of land divestiture was whether TIMOs and REITs would manage their land—investing in regeneration, stand improvement, and health protection—much as the former corporate owners did. In short, would these lands continue to provide raw materials for the forest products industry? Additional uncertainty was created by the short time frames in many TIMO investment plans—10 to 20 years—before the investment needed to be liquidated or recapitalized. A report by Oswalt et al. (2014) found that TIMOs and REITs are indeed managing for commercial timber. The typical arrangement is for a TIMO to enter into a long-term wood supply agreement with a mill, and for these agreements to convey with the land if it is sold (Radcliffe 2008). So the initial uncertainties about long-term fiber supplies are largely gone.

Major differences

The significant differences in public versus private landownership between the two countries strongly influence land management laws, policies, regulations, and practices. These differences lead to notable differences in wood harvest volumes (Table 1). In the United States, 58 percent of forestland and woodland is privately owned, one third of it by private industrial firms (including TIMOs and REITs) and two thirds by private nonindustrial owners (Oswalt and Smith 2014a). Further, 89 percent of the annual harvest comes from private lands. National forests provide only 3 percent, and the remaining 8 percent comes from other public land. In Canada, 94 percent of forestland is public, and only 6 percent is privately owned. Dansereau and deMarsh (2003) reported that 6.4 million ha was held by private industrial firms and 19.56

million ha by private woodlot owners.[1] The annual production from all private forestland in Canada is only 19 percent of Canada's annual wood supply. The other 81 percent of annual harvest in Canada comes from provincial Crown land.

Table 1. Forestland and woodland area and wood volume harvested, by ownership class, 2012

	Canada				United States			
	Area		Volume harvested		Area		Volume harvested	
	Million ha	*Percentage*	*1000 m^3*	*Percentage*	*Million ha*	*Percentage*	*1000 m^3*	*Percentage*
Total area	388.4	100	151,978	100	331.6	100	363,976	100
Public ownership	362.3	94	123,102	81	138.7	42	40,531	11
Private ownership	25.1	6	28,876	19	192.9	58	323,445	89

Sources: The State of Canada's Forests (2014), Oswalt and Smith (2014b)

In both countries, private landownership is concentrated east of the Great Plains: 77 percent of the private forestland is in the eastern provinces and states. But because the bulk of Canada's forests are Crown lands, private lands account for only 16 percent of forestland in the eastern provinces (mostly in Quebec and Ontario) and 5 percent of forestland in western Canada.

The differences in the two countries' forestland ownership patterns have implications for forest policies and management. In the United States, where private ownership is dominant, the 50 state governments each set their own policies for forest management. State governments also implement many federal policies and regulations concerning forests, tailoring activities to their social, political, and economic realities and especially the role of private landowners as the foundation for the wood products manufacturing industry. What consistency does exist is largely due to market forces and to technical assistance and incentive programs funded by the federal government and delivered through state forestry agencies. In Canada, where 90 percent of forestland is Crown land held by the ten provincial and three territorial governments, these latter jurisdictions take the lead in setting and implementing forest management policies. Federal policies and regulations regarding forests are a matter of considerable debate with and among the provincial and territorial governments.

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[1] Rotherham (2003) reports a different area for private industrial firms, 4.8 million ha, and attributes the number to Dansereau and deMarsh (2003).

Land cover status and trends

Land cover change analysis has made remarkable progress in the past 20 years because of the shift from aerial film photography to digital imagery from sensors on satellites or aircraft and greatly increased computing power. The most useful sensors for land cover analyses at a broad landscape scale are the 30-meter Thematic Mapper (TM) sensor on the LANDSAT platform and the 200-meter MODIS sensors on the TERRA and AQUA platforms. Another development involves high-resolution sensors and synthetic aperture radar, called LIDAR. But not many operational monitoring programmes are using LIDAR at the spatial scale of provinces or large states. LIDAR imagery is more appropriate for smaller spatial scales because the very large and dense LIDAR data sets require substantial storage and high-speed processors for analysis.

Beyond better sensors and digital imagery, geospatial analysis software has also become more available and powerful. In the 1990s, geospatial software generally required dedicated workstations and software. In 1999, software was introduced that ran on the Microsoft Windows operating system. This vastly expanded the pool of users and allowed an integrated set of tools for creating, analyzing, and storing geospatial data and information products that were more accessible to analysts and policymakers. The recent introduction of cloud-based computing has also made geospatial information products more widely available.

These new tools are increasingly being used by governments and nongovernmental organizations at all spatial scales for decision making. One advantage of these products is the data layers behind them, which when used with advanced geospatial software can help local and county governments, state and provincial governments, and federal agencies make better policies, set better priorities, and plan better management activities. With the data openly available to all, citizens are better able to visualize and participate in policymaking and decision making. Indeed, better data lead to better dialogue, which leads to better decisions.

These advances support improved data sets and maps for tracking land cover change. Under the auspices of the UN Food and Agriculture Organization's North American Forestry Commission (NAFC), a team of experts from Canada, Mexico, and the United States worked for more than a decade to develop an ecoregional database that can generate consistent tables and maps of forests across all three countries (Figure 2). A second team of experts, working as the North American Land Change Monitoring System (NALCMS) under the auspices of the Commission for Environmental Cooperation, has produced a land over transition matrix (Table 2) and an ecological zone map (Figure 3). It has also analyzed the causes of tree cover changes and found that large fires were more prevalent in more northerly latitudes in Yukon, Alberta, Saskatchewan, and Quebec, while fires were smaller and spread out more extensively in the southern parts of those provinces. The effect of mountain pine beetle infestations was also obvious in central British Columbia.

The transition matrix for Canada, Mexico, and the United States shows common shifts:

- needle-leaved forest → shrubland and herbaceous land;
- mixed forest → deciduous forest, shrubland, and herbaceous land;
- shrub land → deciduous forest and mixed forest;
- herbaceous → shrubland;
- wetland → needle-leaved forest;
- cropland → herbaceous and urban or built-up areas;
- water → barren land; and
- snow and ice → barren land and needle-leaved forest.

On a percentage basis, the largest declines were needle-leaved forest (−2.17 percent) and wetlands (−0.84 percent). The largest increases were in herbaceous cover (+2.36 percent), deciduous forest (+1.22 percent), and shrub land (+0.68 percent). The remaining changes were all less than ± 0.3 percent.

Table 2. North American land cover transition matrix, 2005–2010 (hectares)

	Hectares	2010											
		Needleleaf forest	Deciduous forest	Mixed forest	Shrubland	Herbaceous	Lichen\ mosses	Wetland	Cropland	Barren lands	Urban and built-up	Water	Snow and

2005	Needleleaf forest	363 056 506	267 012	897 450	3 529 668	5 143 256	31 625	70 418	45 806	82 031	19 025	132 993	118
	Deciduous forest	79 050	192 485 950	569 093	171 906	105 912	775	18 275	101 543	3 787	31 962	15 487	106
	Mixed forest	460 700	1 169 593	135 352 643	779 156	758 068	1 725	51 737	22 825	6 956	1 712	26 750	50
	Shrubland	847 418	1 504 318	1 209 343	353 016 700	777 612	27 062	58 831	137 925	29 275	6 750	50 531	143
	Herbaceous	416 562	282 837	343 506	2 075 956	163 139 950	75 387	29 706	354 531	12 687	8 987	62 800	125
	Lichens and mosses	16 737	1 743	1 225	42 387	47 587	228 808 750	362	6	1 600	0	768	81
	Wetland	219 981	74 043	141 906	195 093	212 600	1 806	74 132 168	25 650	8 931	9 606	66 425	68
	Cropland	35 743	127 375	3287	228 625	506 275	18	52 175	293 626 568	6 512	72 400	101 193	50
	Barren lands	12 868	956	87	19 743	21 943	3 762	4 200	52 418	118 966 443	3 737	27 243	987
	Urban and	10 175	12 612	556	5 606	2 850	0	5 281	35 775	1 956	23 802 468	5 687	6

	built-up												
	Water	19 537	11 400	12 706	34 675	16 056	568	35 712	13 650	63 337	2 356	128 99 6 581	13 7
	Snow and ice	468	18	0	418	68	18	31	0	1031	0	2543	30 93 86 68

Source: CEC (2014)

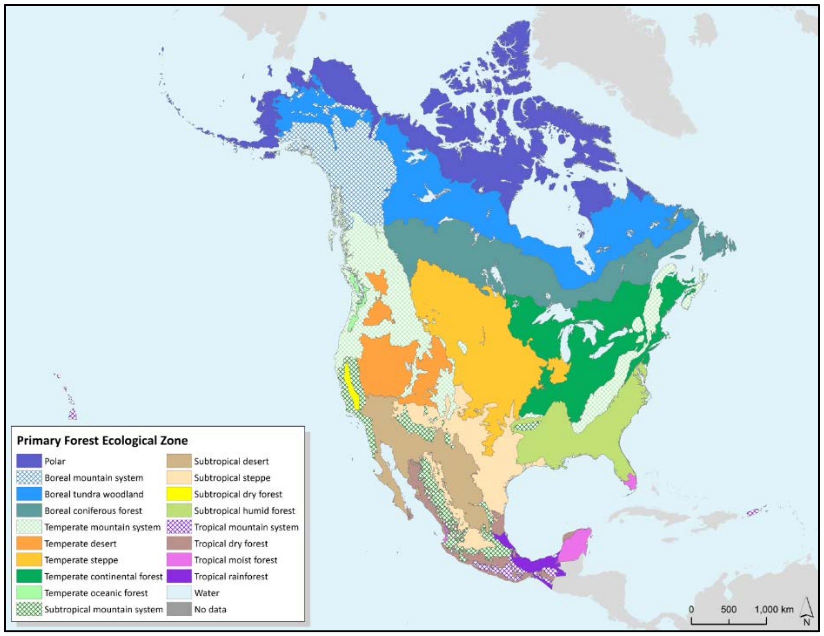

Figure 2. North American ecological zones, 2011

Source: CEC (2011)

Canada

The Canada Center for Remote Sensing has produced national-scale land cover databases with 1 km spatial resolution, including the land cover time series 1985–2005 from the U.S. National Oceanic and Atmospheric Administration (NOAA) advanced very high resolution radiometer (AVHRR) (Latifovic and Pouliot 2005) and SPOT/VEGETATION data (Latifovic et al. 2004). The most recent land cover database of Canada, produced from 0.25 km spatial resolution MODIS data, has improved accuracy, spatial resolution, and thematic content (http://www.nrcan.gc.ca/earth-sciences/land-surface-vegetation/land-cover/north-american-landcover/9146#_North_American_Land). It includes two thematic layers based on the Federal Geographic Data Committee/Vegetation Classification Standard, modified for use in Canada, and the International Geosphere Biosphere Program land cover classes. The new database served as the primary source of Canadian land cover information in the North American Land Cover Database.

The effect of the mountain pine beetle outbreak in central British Columbia is evident in that new MODIS-derived map. In subsequent work reported by BiodivCanada, transitions from tree cover to other cover classes, and from other cover classes back to forest, were also depicted.

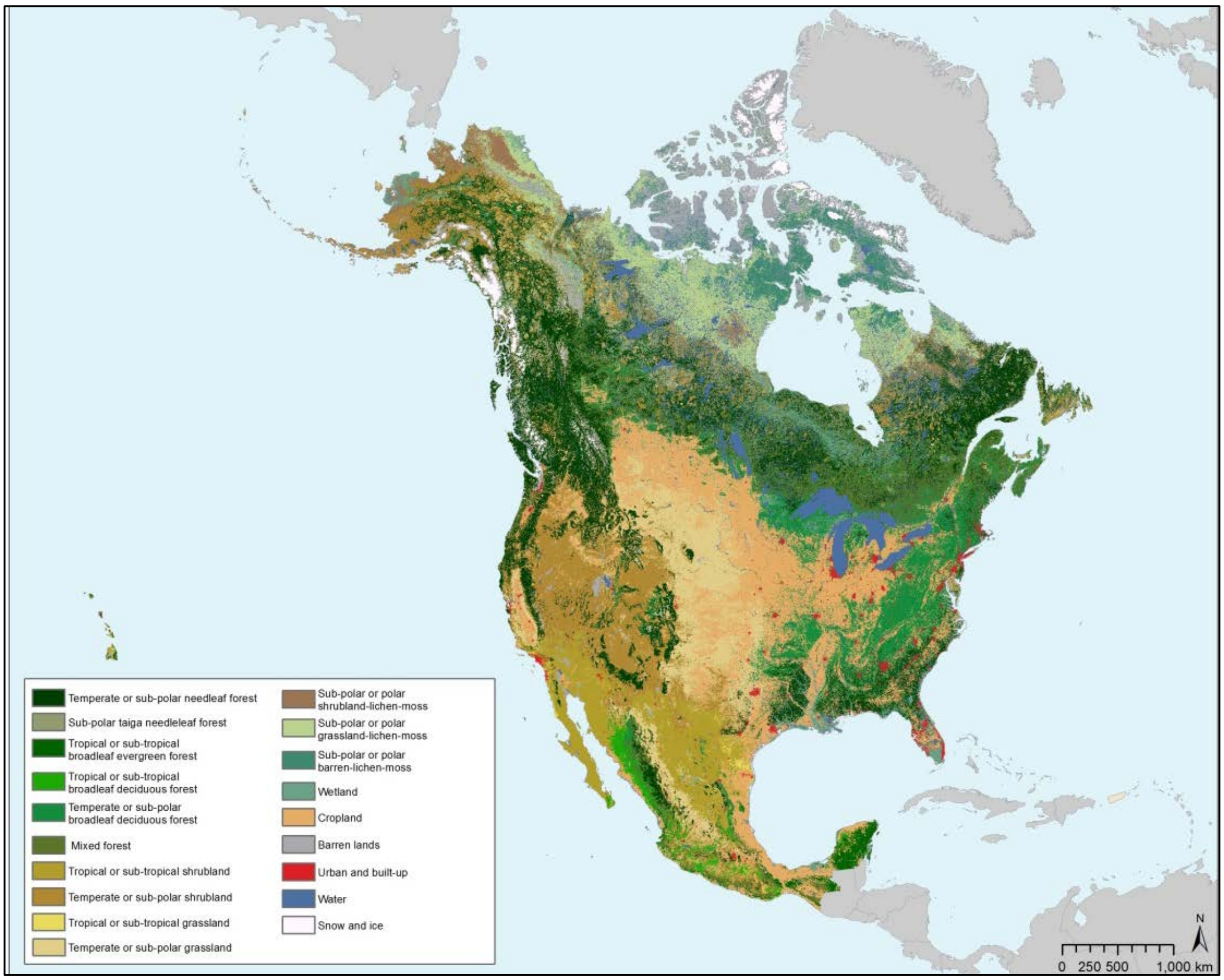

Figure 3. North American land cover, 2010

Source: CEC (2010)

United States

In 1993, U.S. Forest Service researchers produced the first national map of forest cover based on satellite imagery from NOAA's AVHRR satellites in combination with field data from the agency's Forest Inventory and Analysis program (Zhu and Evans 1994) (http://www.fia.fs.fed.us/library/maps/). Following the success of this project, seven federal agencies combined their expertise and funding under the auspices of the Multi-Resolution Land Characteristics Consortium (http://www.mrlc.gov) to produce the National Land Cover Dataset (NLCD). Maps of increasingly higher quality resolution, based on TM and MODIS imagery and with richer sets of characteristics, were developed in 2001, 2006, and 2011.

The National Land Cover Database 2011 is the most recent national land cover product created by the consortium (Figure 4). It provides, for the first time, the capability to assess wall-to-wall, spatially explicit, national land cover changes and trends across the country for 2001–2011. As with two previous NLCD products, NLCD 2011 keeps the same 16-class land cover classification that has been applied consistently across the country at a spatial resolution of 30 meters. NLCD 2011 is based primarily on a decision-tree classification of Landsat satellite data. Details of the construction of NLCD 2011 are in Homer et al. (2015).

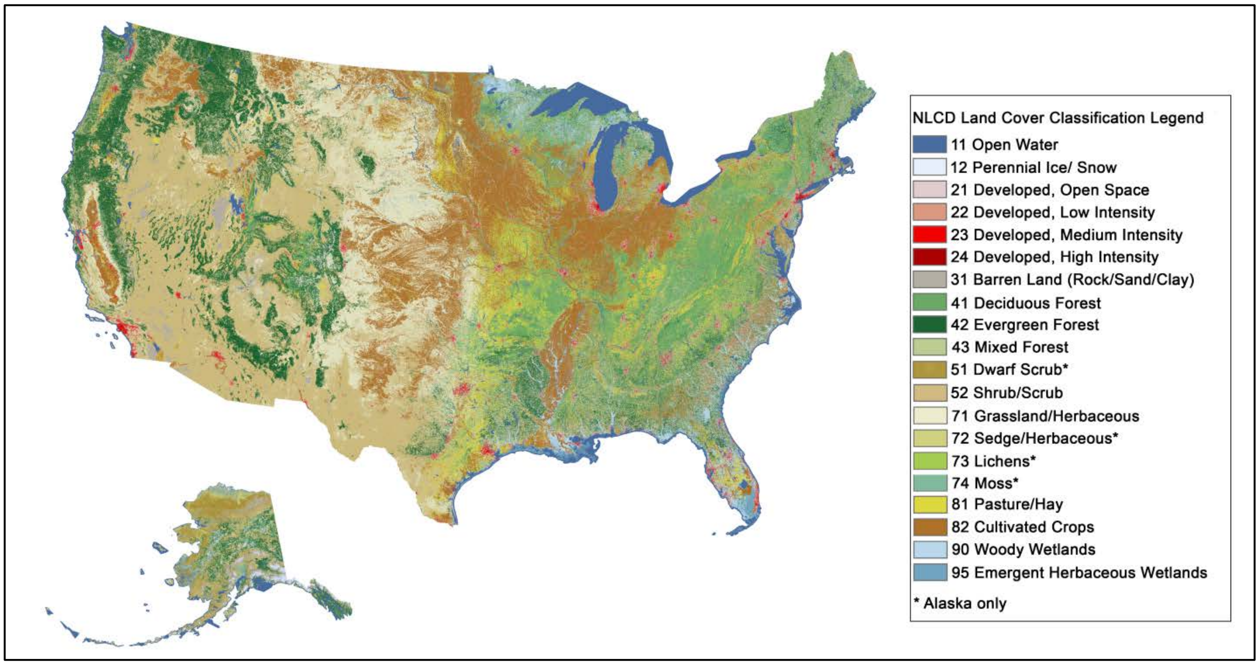

Figure 4. U.S. land cover, 2011

Source: Homer et al. (2015)

Homer et al. (2015) also developed a land cover transition matrix and associated graphics from the NLCD products that show change from 2001 to 2011 (Figure 5). Most areas with tree cover losses showed up as shrub or herbaceous cover gains, and most of the shrub or herbaceous cover losses showed up as gains to one of the tree cover types. The vast majority of these shifts back and forth between tree cover and shrub or herbaceous cover are normal, temporary changes associated with active forest management. For example, if a partial cutting to promote natural regeneration reduces tree cover below 25 percent, satellite imagery can no longer detect trees as the dominant land cover, and image classification may then shift to shrub or herbaceous cover. When the young, newly established trees—whether regenerated by seed from the remaining trees or by the planting of seedlings—grow tall enough and their crowns expand to provide more than 25 percent tree cover, then image classification changes back to tree cover. This shift normally takes 10 years in southern forests and 15 to 20 years in northern and western forests. Some analysts (Hansen et al. 2010) have mistakenly concluded from two sets of imagery only five years apart that "deforestation" has occurred, and this has led to exaggerated reports (Rice 2010). That term should be used only when a permanent shift from tree cover to nontree cover has occurred and is documented over a longer time series of earth observations (Reams et al. 2010).

Similarly, the term "afforestation" should be reserved for a permanent shift to tree cover from herbaceous or shrub cover.

The figures also show that transitions within and among the cultivated crops and pasture bars than the changes within and among the evergreen, deciduous, and mixed forest cover bars. There are some changes back and forth between pasture (intensively managed) and herbaceous (unmanaged) grass cover as herbaceous and pasturelands move into and out of cultivation. Interestingly, a significant segment of red on the loss side of the cultivated crops category indicates loss of cropland to development. That red area appears larger than the loss of tree-covered land to development, and the transition matrix data confirm a loss of 3.84 million hectares (0.47 percent) of cultivated cropland and pasture to development between 2001 and 2011, versus the loss of 2.33 million hectares (0.25 percent) of tree-covered land to development. In the developed land categories, we see a significant movement from open space or low-density development to more intensively developed areas in 2011. The transitions in developed land confirm the changes discussed in the land-use section (above): as the urban U.S. population grows, developed areas are both expanding at the expense of other land cover types and increasing in development intensity.

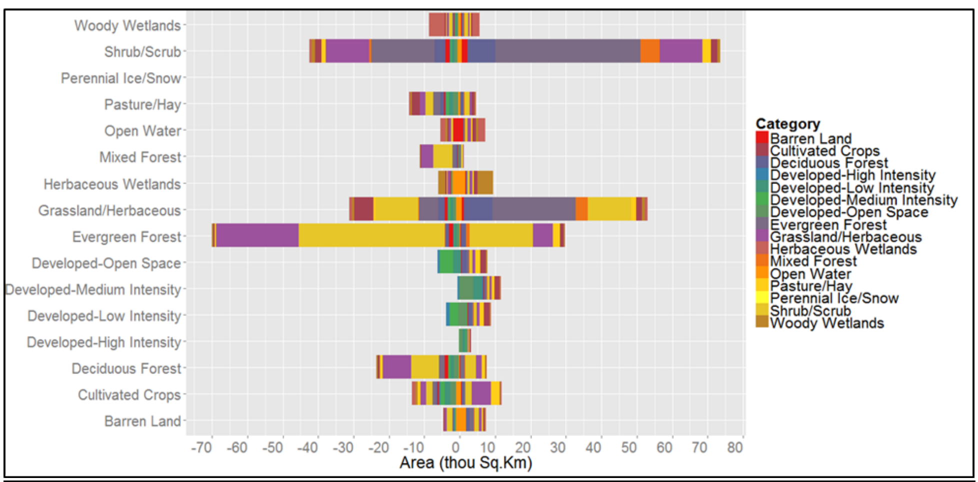

Figure 5. Land cover change in United States, 2001–2011

Land-use status and trends

For many, “North America” evokes an image of open spaces, endless forests, mighty rivers, and prairies stretching to the horizon. Although such a view has motivated efforts to protect some of the region’s majestic places, the perception that North America’s natural resources were inexhaustible, common in the 1800s, has changed. Canada and the United States have converted landscapes, built infrastructure, and consumed energy on a vast scale. Over four centuries, forests, grasslands, and wetlands have been cleared for agriculture. In the 20th century, some land previously farmed has reverted to forests while other farms have become peri-urban, suburban, and urban areas.

A focus on events since European settlement overlooks the much longer history of the region’s original inhabitants, many of whom struggled with land-use and resource allocation issues that had both biophysical and social-cultural dimensions. Those struggles have only intensified since European settlement. Current controversies over resource development and land use, such as oil and gas extraction, or construction of new electricity transmission or underground pipeline corridors, show that land and resource decisions are still entwined with biophysical and social-cultural questions, including democracy and autonomy.

Recent trends in land-use and land cover change—together with debates over land rights and the processes by which land and resource decisions are made—set the stage for some of the region’s most pressing environmental challenges: habitat fragmentation, the spread of invasive alien species, and the local and cumulative effects of agriculture and resource extraction. Any discussion about the current land-use situation needs to consider both the long-term changes in land use since European settlement of North America as well as changes since the middle of the 20th century.

Since the end of World War II, development of urban, suburban, and peri-urban areas has been a dominating factor in North American land-use changes, driven in large part by an early-20th-century technological innovation—the automobile. The United States, with 240 million cars, and Canada, with 17 million, together have one quarter of the world’s total number of vehicles, 1.015 billion (Davis 2014; Sousanis 2011). Public transit in Canada serves less than one in five commuters; the U.S. figure is one in 20 (McKenzie and Rapino 2011).

By allowing flexibility in routing and timing of commuting, the automobile contributed to America’s less dense, less compact urban development (Jackson 1985; Hofmann et al. 2005).

Elsewhere, urban expansion was more heavily influenced by the hub-and-spoke patterns of surface rail and streetcar transit or the grid pattern associated with early pedestrian-oriented cities (Jackson 1985). The increase in automobiles was one of the principal forces that drove decentralization of the workplace and greater physical separation of home from work (Baum-Show 2010). Many North American developed landscapes now include low-density residential and commercial development predicated on automobile usage. Suburban and peri-urban residents are often unwilling to pay the taxes and fares associated with building and operating convenient and frequent public transit to serve them (McKenzie 2015). Truly, the land-use situation in North America has been driven by development patterns mightily influenced by automobile use.

Thanks to insights gained through monitoring programs, satellite imagery, and computer-assisted ecological classification systems, the understanding of land cover change has been growing over the past two decades, and this understanding can inform management strategies. Governments and academics have adopted standard greenhouse gas inventory systems established by the United Nations Framework Convention on Climate Change (UNFCCC), and the Intergovernmental Panel on Climate Change has developed concepts and research on land use, land-use change, and forestry (Watson et al. 2000). Together, these measures offer opportunities to link evidence to policy and practice in support of sustainable and equitable land decisions.

Both countries prepare national communications, inventory reports, and tables for the UNFCCC using the same definitions. These reports, however, cover only *managed* land (Table 3), and 71 percent of Canada's land is considered unmanaged for UNFCCC reporting purposes. Both countries conduct national inventories of their forests and report information to UNFAO using standard definitions as part of its global forest resources assessment process. But the Canadian report to UNFAO includes 50 percent more forestland than is reported to UNFCCC. The inconsistency between the reporting requirements of the two processes complicates yet a third analysis—the UN Environmental Programme's sixth Global Environmental Outlook report--because different numbers exist in the published literature for the same land uses.

Both countries also produce agricultural censuses every five years that provide detailed analyses of changes in land use associated with farming and ranching. The shifts in production, driven by market signals and policy changes, have consequences for the environment (via greenhouse gas emissions) as well as for rural economies.

Based on data from all those sources, three types of land-use change emerge as most significant in recent years:

- forest to cropland;
- cropland to settlement; and
- forest to settlement.

Canada

Between 1989 and 2006, the amount of cropland in Canada rose by around 1 percent per year net, primarily involving land-use shifts of forest to cropland and vice versa (Environment Canada 2014; Statistics Canada 2012a). But the trend over the past 25 years indicates a slowing of this net growth in cropland. At the national scale, the forest-to-cropland changes have ranged from +2.6 percent of cropland area for 1989–1990, to +1.3 per cent in 2004–2005, to +1 percent for 2009–2010. The annual cropland-to-forest changes have been about one fifth of the forest-to-cropland shifts. In absolute terms, from 1993 to 2013, 405,000 ha of Canadian forestland was converted to cropland use. This is down from the 1.286 million ha of forest converted to cropland from 1970 to 1990.

Farmland conversion to forest has been more common in eastern Canada. Since 1993, 83 percent of forest-to-cropland conversions occurred in eastern Canada and only 10 percent in the Prairie provinces. The cropland-to-forest changes have occurred largely where privately owned marginal cropland is taken out of production and planted to trees. This transition has primarily affected cropland where production was abandoned some years ago (e.g., old Christmas tree plantations, old vineyards, old fields that naturally transitioned to woody species), and the regrowth now meets the definition of forest cover. The area of marginal cropland left to naturally transition to forest has not been quantified by either the current national forest inventory program or the Canadian Census of Agriculture. Marginal agricultural land remains classified as cropland until sufficient tree cover emerges to meet the forest definition.

Table 3. Land-use trends in Canada and United States (thousand ha)

Land-use categories	1990	2005	2010	2013
	---------------------------------- *Ha (thousand)* --			
UNITED STATES				
Forest[1]	298,598	300,848	302,033	302,386
Croplands	170,448	160,107	159,243	159,230
Grasslands	350,109	347,142	346,439	346,430
Settlements	38,602	49,676	50,624	50,614
Wetlands	44,453	44,060	43,330	43,025
Other land[2]	34,021	34,397	34,562	34,545
U.S. subtotal	936,231	936,230	936,231	936,230
CANADA	1990	2005	2010	2013
Forest[1]	232,715	232,085	231,847	231,709
Croplands[3]	49,120	50,018	50,152	50,236
Grasslands	7,890	7,399	7,253	7,166
Settlements	1,881	2,214	2,360	2,411
Wetlands[4]	1,065	453	521	519
Other land (Unmanaged forest and wetland)	705,796 (265,220)	706,298 (355,462)	706,334 (265,632)	706,426 (265,772)
Canada subtotal	998,467	998,467	998,467	998,467

Unfortunately, inventories and monitoring programs relied on for estimating land-use changes for greenhouse gas reporting do not currently estimate the amount of cropland converted to development. However, other reports have documented significant changes. Canada's agricultural land is classified based on its quality and constraints for production. The top three classes are called "dependable agricultural land" (DAL) and total 49.3 million hectares. DAL is valuable because it has no severe constraints on production and because it is scarce—only 5 percent of all agriculture land. Hofmann (2001) found that from 1971 to 1996, urban areas had consumed 1.2 million hectares of land, half of that being DAL. By 1996, urban areas covered 2.8 million hectares across Canada, and 52 percent of the urban area was DAL. Hofmann et al. (2005) reported further loss of DAL to development, reporting that in 2001, urban areas occupied 3 percent of all DAL and, more importantly, 7.5 percent of Class 1 DAL. When urban and rural built-up areas are combined with transportation and utility corridors and other developed land, 4 million acres of DAL—8.1 percent of the nation's endowment—was in nonagricultural land use. A corroborating analysis by Statistics Canada (2014) found that settlements on DAL increased by 19 percent from 2000 to 2011. By ecozone, the largest increase of urban intrusion DAL occurred in the Mixedwood Plains (along the St. Lawrence River), where development on DAL grew by 128 030 hectares (+27 percent). More than half this growth was in the Greater Golden Horseshoe region (the western end of Lake Ontario). The second-largest increase was noted in the Prairies ecozone, where development of DAL increased 59,807 hectares (+16 percent). Given that many of the population centers experiencing growth are located near productive farmland, it appears that the loss of some of Canada's best farmland will likely continue.

Conversion of other land uses to settlement also continues. In the four years from 2010 to 2014, development added 499,600 ha, the vast majority of it (498,790 ha) from forestland (Environment Canada 2014). A small amount of grassland (820 ha)—mostly tundra in far northern regions—also was converted to settlements. Although the conversion of forest to development was tiny (0.13 percent), it demonstrates that forest areas surrounding settlements are a target for urban expansion.

United States

Forests account for 30 percent of the U.S. land area; grazing and pasturelands, 27 percent; cropland, 18 percent; and urban areas, 3 percent. The proportions vary widely by region. The Great Plains and Rocky Mountain regions together have more than three quarters of the nation's grazing land and a third of the cropland. The northern states have the highest percentage of land in forests (41 percent) and 35 percent of the nation's cropland, while the southern states have the largest percentage of the nation's timberland, defined as forests with no constraints on harvesting wood (40 percent). Population is heavily concentrated. In the West, 90 percent of the population lives in urban areas; for the Northeast, the figure is 85 percent, and for the Midwest and South, 76 percent (U.S. Census Bureau 2012).

Cropland trends. The land area dedicated to crop production in 2012 was 146.9 million hectares—an increase of 1.56 million hectares since 2007 and the first reported increase since 1982 (USDA NASS 2015; Figure 6). Despite this recent overall gain, the longer-term trend was loss of cropland. Increases in urban land are responsible for part of this decline. Trends in land-use change since 2007 have not been analyzed in a comprehensive way because updated information from the Natural Resources Conservation Service's inventory reports is absent.

Between 2007 and 2012, the Conservation Reserve Program, which provided financial incentives to farmers to take highly erodible and other marginal land out of production, lost 3.34 million hectares, nearly 2.22 million hectares of which (77 percent) had been planted grasslands and lands formerly used for pasture or hay production. Lark et al. (2015) found that the principal crops grown on this new cropland were maize (26 percent), wheat (25 percent), soybeans (20 percent), and alfalfa (7 percent), but they did not attribute the crop production gains to any particular driving force, such as shifting commodity prices or biofuels mandates.

Developed land increased by 1.23 million hectares (2.7 percent), 46 percent of which was converted forest, 37 percent rangeland and pastureland, and 23 percent cropland.

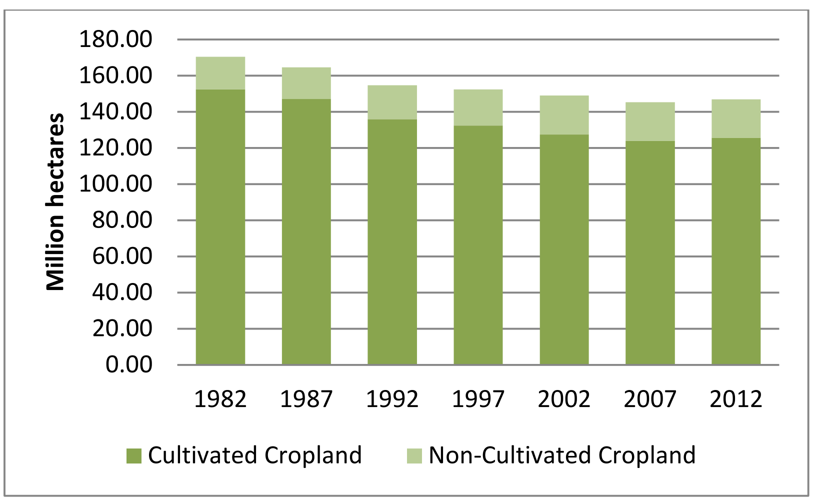

Figure 6. U.S. cropland, 1982–2012

Source: USDA Natural Resources Conservation Service (2015)

Grazing land trends. Pastureland and grazing land estimates vary, depending on the data source and definitions. The National Resources Inventory (NRI) of the Natural Resources Conservation Service classifies 49 million hectares as pasture and 164.2 million hectares as rangeland, for a total of about 213 million hectares (USDA NRCS 2015). The 2012 Census of Agriculture, on the other hand, classifies 168.1 million hectares as pasture or rangeland for grazing, plus 11.3 million hectares of grazed woodland, for a total of 175.4 million hectares, an increase of 7.3 million hectares since 2007 (USDA NASS 2014). A broader estimate of land available for grazing from a third Department of Agriculture agency, the Economic Research Service, totals about 248.7 million hectares; it includes grassland and other nonforested pasture and rangeland (USDA ERS 2015). If forestlands used for grazing and cropland pasture are also included, the total 2007 estimate for grazing lands is 314.4 million hectares, representing 35 percent of U.S. land area (US EPA 2010). However, three- to four-year delays in the release of NRI information from the 2007 and 2012 surveys have prevented the Economic Research Service from updating Nickerson et al. (2011; Figure 7). This lack of timeliness in processing and releasing data compromises the usefulness of the NRI to decision makers and policymakers and causes confusion for analysts.

Forestland trends. Forests are managed by a complex array of interests to meet multiple purposes, including recreation, public water supplies, timber production, and habitat for a variety of species. Oswalt et al. (2014) reported 310 million hectares of forestland in the United States in 2012, of which 211 million hectares was considered timberland. Forests that are not timberland include land reserved from timber production, such as designated wilderness areas and national parks, or land with tree cover where other factors, such as steep slopes, constrain timber harvesting. There were 29.7 million hectares in the “reserved” category and 69.4 million hectares in the “other” category in 2012. From 2007 to 2012, the area of timberland grew by just over 2.8 million hectares and the area of forest by 5.7 million hectares, implying that forestland identified as “reserved” or “other” also gained 2.8 million hectares. This total reflects a net gain over five years of about 14.6 million hectares (6 percent), which is attributed largely to reversion of pasture and other agricultural lands to forest, as well as reclassification of some national forest lands to align with classifications used on other landownerships (Oswalt et al. 2014).

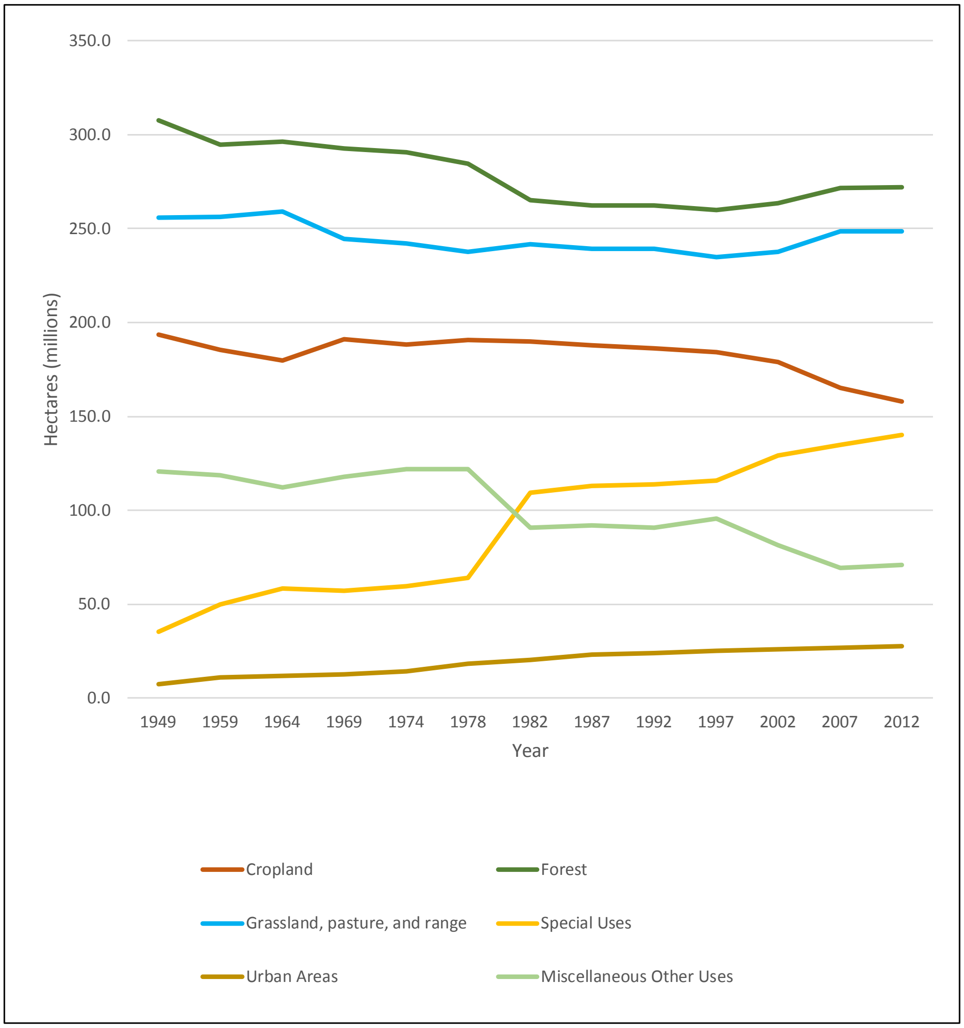

Figure 7. Major U.S. land uses, 1949–2007

Source: Adapted from Nickerson et al. (2011)

Urban and development trends. The number of people living in rural counties stood at 46.2 million in 2014 and accounted for nearly 15 percent of the population spread across 72 percent of the nation's land. Rural areas lost population to developed urban and suburban areas between July 2013 and July 2014, continuing a four-year trend. Rural population growth from net migration peaked in 2006, then declined precipitously and shifted geographically in response to rising unemployment, housing market challenges, and energy sector developments, among other factors. Suburban expansion and migration to scenic retirement or recreation destinations have been primary drivers of rural demographic change for several decades, but since the onset of the 2007–2008 recession, their influence has considerably weakened (USDA ERS 2015; Figure 8).

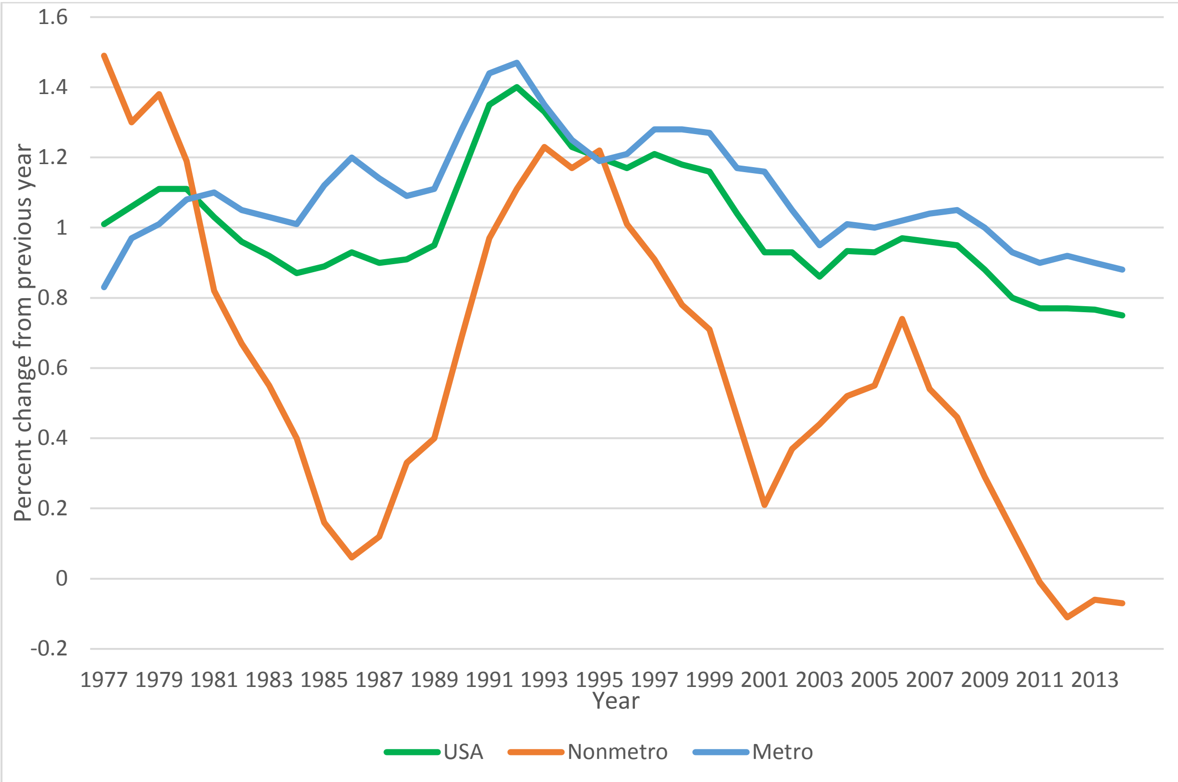

Figure 8. Population change, by metropolitan and nonmetropolitan census status, 1976–2014

Source: USDA Economic Research Service (2015)

The loss of population and decline in rural communities reflects a "hollowing out" of the vast central regions of the country, where both agriculture and industry drove economic growth and middle-class prosperity in the second half of the 20th century. Although many studies document the departure of young people, ages 20–24, from rural areas and characterize it as a "brain drain," a recent study by Cromartie et al. (2015) offers some hope. In that study, people returning to settle in rural areas were interviewed to determine their reasons and assess barriers. The majority of the returnees were in their early to mid-30s with young children. Their primary motivations for returning included being closer to relatives, proximity to outdoor recreation (camping, fishing, and hunting were prominently mentioned), opportunities for civic leadership and volunteering, and shorter commutes to work. The primary barriers were low wages and lack of career opportunities, lack of cultural events, and limited amenities, shopping, and dining options. The rural communities benefited from an influx of well-educated professionals who brought creative strategies, business contacts, leadership skills, and an interest in community well-being, especially primary and secondary education. Thus rural counties experiencing population growth may be at the forefront of benefiting from the returnees' talents. Increasing in-migration to rural areas and stemming the departure of young people will require local civic and political leadership capable of dealing with complex cultural and socioeconomic factors while keeping the local economy and local landscapes healthy and resilient.

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