From:	Jeffrey Delapena
To:	Tim Trohimovich
Cc:	Oliver Orjiako; Jose Alvarez
Subject:	FW: Comments on the Comp Plan Update Introduction, Ch 1 Land Use Element, and Ch 3 Rural and Natural Resource Element
Date:	Thursday, June 18, 2026 8:09:00 AM
Attachments:	image.png image.png image.png Guide for authors - Energy Policy.pdf Blame_the_exurbs_not_the_suburbs_Explori.pdf Issue Paper_9_Supplemental Resource Land Info_2016_0623_CLEAN.pdf Preserving Prime Farmland in the Face of Urbanization Lessons from Oregon JAPA.pdf JAPA Instructions for Authors.pdf Compact Development Reduces VMT Evidence and Application for Planners Comment on Does Compact Development Make People Drive Less.pdf 2026-06-18 FW Comments on Land Use and Rural Comp Plan Update PC.pdf CountyGHGAnalysisReport_Clark_20260123.pdf image001.png image002.png image003.png image004.png

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Good day, Tim,

Thank you for providing Futurewise's feedback related to tonight's Planning Commission Work Session regarding the Comprehensive Plan Chapter Review.

I am forwarding to additional members of Staff. Your comments will be brought to the attention of the Planning Commission ahead of tonight's meeting. This will also be added to the Index of Record.

Best,

Jeff Delapena
Program Assistant
COMMUNITY PLANNING

564.397.4558

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From: Tim Trohimovich <Tim@futurewise.org>
Sent: Wednesday, June 17, 2026 6:41 PM
To: Cnty 2025 Comp Plan <comp.plan@clark.wa.gov>; Jeffrey Delapena <Jeffrey.Delapena@clark.wa.gov>
Subject: Re: Comments on the Comp Plan Update Introduction, Ch 1 Land Use Element, and Ch 3 Rural and Natural Resource Element

EXTERNAL: This email originated from outside of Clark County. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi:

Here is the second and final set.

Tim Trohimovich, AICP
Director of Planning & Law
Futurewise
1201 3rd Ave #2200, Seattle, WA 98101
(206) 343-0681
tim@futurewise.org

From: Tim Trohimovich <Tim@futurewise.org>
Sent: Wednesday, June 17, 2026 6:32 PM
To: Cnty 2025 Comp Plan <comp.plan@clark.wa.gov>; Jeffrey Delapena <jeffrey.delapena@clark.wa.gov>
Subject: Re: Comments on the Comp Plan Update Introduction, Ch 1 Land Use Element, and Ch 3 Rural and Natural Resource Element

Dear Commissioners and Staff:

Here is the first selected enclosure.

Tim Trohimovich, AICP
Director of Planning & Law
Futurewise
1201 3rd Ave #2200, Seattle, WA 98101
(206) 343-0681
tim@futurewise.org

From: Tim Trohimovich <Tim@futurewise.org>
Sent: Wednesday, June 17, 2026 6:30 PM
To: Cnty 2025 Comp Plan <comp.plan@clark.wa.gov>; Jeffrey Delapena <jeffrey.delapena@clark.wa.gov>
Subject: Comments on the Comp Plan Update Introduction, Ch 1 Land Use Element, and Ch 3 Rural and Natural Resource Element

Dear Planning Commissioners and Staff:

Enclosed please find Futurewise's comments on the Introduction, Chapter 1 Land Use Element, and Chapter 3 Rural and Natural Resource Element of the Clark County Comprehensive Plan Update. We will also be emailing the selected enclosures indicated in the letter in separate emails.

Thank you for considering our comments. If need anything else, please let me know.

Tim Trohimovich, AICP (he/him)
Director of Planning & Law

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June 18, 2026

Karl Johnson, Chair
Clark County Planning Commission
Clark County Community Planning
PO Box 9810
Vancouver, Washington 98666-9810

Dear Chair Johnson and Planning Commissioners:

Subject: Comments on the Introduction, Chapter 1 Land Use Element, and Chapter 3 Rural and Natural Resource Element of the Clark County Comprehensive Plan Update
Sent via email: comp.plan@clark.wa.gov; jeffrey.delapena@clark.wa.gov;

Thank you for the opportunity to comment on the Introduction, Chapter 1 Land Use Element, and Chapter 3 Rural and Natural Resource Element of the Clark County Comprehensive Plan Update. Futurewise works throughout Washington State to support land-use policies that encourage healthy, equitable, and opportunity-rich communities, and that protect our most valuable farmlands, forests, and water resources. Futurewise has members and supporters across Washington State including in Clark County.

Summary of the Recommendations

Futurewise has the following comments and recommendations on the Introduction, Chapter 1 Land Use Element, and Chapter 3 Rural and Natural Resource Element:

- Futurewise strongly supports including a Tribal Land Acknowledgement that has the agreement of the Tribes and Indian Nations affected by the county comprehensive plan.
- Because urban area expansions are not needed, the Land Use Element and Future Land Use Map cannot expand the urban growth areas (UGAs). Expanding the UGAs would violate the Growth Management Act (GMA). Please see page 2Because urban area expansions are not needed, the Land Use Element and Future Land Use Map cannot expand the urban growth areas (UGAs). of this letter for more information.
- The UGAs must not be expanded onto agricultural lands of long-term commercial significance and the Land Use Element and Future Land Use Map

should designate the "Agricultural Land Base" lands that meet the criteria for agricultural lands of long-term commercial significance as agricultural lands of long-term commercial significance. This is necessary to comply with the GMA. Please see page 3 of this letter for more information.

- The Land Use Element and Future Land Use Map must designate adequate land for affordable housing within the urban growth areas (UGAs). This is necessary to comply with the GMA. Please see page 4 of this letter for more information.
- The Land Use Element and Future Land Use Map should focus these densities and housing units in transit-oriented development locations within the UGAs. This is necessary to comply with the GMA. Please see page 5 of this letter for more information.
- The Land Use Element, the Future Land Use Map, and the Rural Element should better protect working farms. This is needed to better protect working farms. Please see page 6 of this letter for more information.
- A transfer of development rights program cannot be used as an excuse to expand urban growth areas or dedesignate agricultural lands of long-term commercial significance. Please see page 7 of this letter for more information.
- Reduce planned rural growth and capacity. This will help protect the environment and comply with the GMA. Please see page 8 of this letter for more information.

Detailed Recommendations

Comments on the Introduction

Futurewise strongly supports including a Tribal Land Acknowledgement that has the agreement of the Tribes and Indian Nations affected by the county comprehensive plan.

Comments on Chapter 1 Land Use Element

Because urban area expansions are not needed, the Land Use Element and Future Land Use Map cannot expand the urban growth areas (UGAs).

The Washington State Supreme Court wrote "we hold a county's UGA designation cannot exceed the amount of land necessary to accommodate the urban growth projected by [the Washington State Office of Financial Management] OFM, plus a

reasonable land market supply factor."[1] A comparison of the total 2023-2045 housing unit needs in the *2025 Population, Housing and Employment Allocation – Issue Paper 5* with the "2023 VBLM Capacity" shows that existing capacity can accommodate or is within a few housing units of accommodating the planned housing growth.[2] And the cities and unincorporated urban growth areas will likely need to increase their capacity for low-rise multifamily and mid-rise multifamily dwellings to meet the affordable housing requirements which will increase the housing capacity in the cities and unincorporated urban growth areas.[3] Further, Vancouver, Camas, and Washougal were required to adopt their new middle housing zoning by December 31, 2025, further increasing their housing capacity.[4] So, there is no need to expand the county's urban growth areas. Without a need to expand the urban growth areas, Clark County lacks the legal authority to expand the urban growth areas (UGAs).[5]

The UGAs must not be expanded onto agricultural lands of long-term commercial significance and the Land Use Element and Future Land Use Map should designate the "Agricultural Land Base" lands that meet the criteria for agricultural lands of long-term commercial significance as agricultural lands of long-term commercial significance.

The *Clark County Agricultural Lands Study* documents "that 98 percent of the 101,844-acre Agricultural Land Base (99,900 acres) is classified as having Prime or Statewide Importance soils. A nearly identical share, 96 percent (31,400 acres),

---

[1] *Thurston Cnty. v. W. Washington Growth Mgmt. Hearings Bd.*, 164 Wn.2d 329, 352, 190 P.3d 38, 49 (2008).
[2] Clark County Comprehensive Plan 2025 Update Planning for growth 2025 – 2045 *2025 Population, Housing and Employment Allocation – Issue Paper 5* prepared by Community Planning p. 5; Clark County 2025 Allocation based on VBLM and HAPT Method A p. *1 last accessed on June 17, 2026, at: https://clark.wa.gov/sites/default/files/media/document/2024-02/Allocation%20Housing_Method%20A.pdf and at link on the last page of this letter with the filename: "Allocation Housing_Method A.pdf."
[3] Washington States Department of Commerce, Local Government Division Growth Management Services, *Guidance for Updating Your Housing Element: Updating your housing element to address new requirements* p. 36 (Aug. 2023, updated Jan. 2026) last accessed on June 17, 2026, at: https://www.commerce.wa.gov/growth-management/housing-planning/housing-guidance/ and at the link on the last page of this letter with the filename: "1220_Book2_Housing Element Update_230823 Final_updated 260112.docx."
[4] Washing State Department of Commerce Middle Housing Update Deadlines last accessed on April 23, 2026, at: https://deptofcommerce.app.box.com/s/bv7g03x1h176hwy2lgm8chraykr8ki50 and at the link on the last page of this letter with the filename: "Middle Housing Update Deadlines by Year - Updated May 2025.pdf."
[5] *Thurston Cnty. v. W. Washington Growth Mgmt. Hearings Bd.*, 164 Wn.2d 329, 351 – 52, 190 P.3d 38, 48 – 49 (2008).

is found within the existing 32,589-acre Agricultural Designations. This near-universal prevalence indicates that from a soil-capability perspective, the vast majority of lands identified in the study area are physically well-suited for agricultural production."[6] The other factors also show that these lands qualify as agricultural lands of long-term commercial significance.[7] The Land Use Element and Future Land Use Map must retain the existing agricultural lands of long-term commercial significance designation and add the "Agricultural Land Base" that meet the criteria for agricultural lands of long-term commercial significance to the designated agricultural lands of long-term commercial significance.

The 519 acres that Ridgefield and La Center are requesting to pave over forever are prime agricultural lands and farmlands of statewide importance and meet the other criteria for agricultural lands of long-term commercial significance.[8] Consequently, these lands cannot be legally dedesignated under WAC 365-190-040(10)(c). Since the lands cannot be dedesignated legally, they cannot be legally added to the UGAs unless the land added has been protected for agricultural use through the adoption of a purchase or transfer of its development rights.[9]

In the past Clark County was able to dedesignate agricultural lands of long-term commercial significance that continued to meet the criteria and have them annexed before the Growth Management Hearings Board and the courts found that these dedesignations violated the Growth Management Act. **That is no longer possible because dedesignations and urban growth area expansions do not take effect until after the Growth Management Hearings Board appeals are resolved.[10] So, dedesignations that violate state law are now a waste of time and money as they will be appealed and overturned and cannot be annexed during the appeal period.[11]**

The Land Use Element and Future Land Use Map must designate adequate land for affordable housing within the urban growth areas (UGAs).

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[6] ECOnorthwest, *Clark County Agricultural Lands Study* pp. 62 – 63 (Clark County Planning & Development Department: Nov. 2025) last accessed on June 17, 2026, at: https://clark.wa.gov/sites/default/files/media/document/2025-11/final-agricultural-lands-study-technical-report-2025.11.04-1.pdf and at the link on the last page of this letter with the filename: "final-agricultural-lands-study-technical-report-2025.11.04-1.pdf."
[7] *Id.* pp. 66 – 73.
[8] *Id.* pp. 62 – 73.
[9] RCW 36.70A.060(5).
[10] RCW 36.70A.067.
[11] RCW 36.70A.067.

RCW 36.70A.070(1) requires that the comprehensive plan "shall" include a land use element [and map] designating the proposed general distribution and general location and extent of the uses of land, where appropriate, for agriculture, timber production, housing, ... The land use element shall include population densities, building intensities, and estimates of future population growth." The State of Washington Department of Commerce has documented that to provide housing affordable to families and individuals earning 80 percent or less of the area median income requires low-rise multifamily and mid-rise multifamily housing and potentially accessory dwelling units.[12] To provide housing affordable to families earning more than 80 to 120 percent AMI requires townhomes, duplexes, triplexes, and quadplexes.[13] These multifamily housing types are urban, not rural or resource lands uses. Given the affordable housing targets applied to the Clark County urban growth areas, the Land Use Element and Future Land Use Map must designate adequate land for affordable housing within the urban growth areas.

The Land Use Element and Future Land Use Map should focus these densities and housing units in transit-oriented development locations within the UGAs.

These housing densities when located with mixed uses along transportation corridors and designed consistent with Transit Oriented Development principles is also an important method of reducing greenhouse gas pollution.[14] So the County can provide for affordable housing and reduce greenhouse gas pollution. This will also help comply with the requirements to reduce per capita vehicle miles traveled (VMT) in RCW 36.70A.070(1) and RCW 36.70A.070(9)(c) and (d)(i)(B) and to reduce greenhouse gas pollution in RCW 36.70A.070(9)(c) and (d)(i)(A). Indeed, the most effective way to reduce per capita VMT is to focus growth into existing

[12] Washington States Department of Commerce, Local Government Division Growth Management Services, *Guidance for Updating Your Housing Element: Updating your housing element to address new requirements* p. 36 (Aug. 2023, updated Jan. 2026) last accessed on June 17, 2026, at: https://www.commerce.wa.gov/growth-management/housing-planning/housing-guidance/ and at the link on the last page of this letter with the filename: "HB 1220_Book2_Housing Element Update_230823 Final_updated 260112.pdf."
[13] *Id.*
[14] Wash. State Dep't of Commerce Growth Management Services, Clark County 2022 Greenhouse Gas Emissions Analysis p. 26, pp. C-1 – C-2 (v3.5.1) last accessed on June 17, 2026, at: https://www.commerce.wa.gov/growth-management/climate-planning/climate-policy-tools/ enclosed at the link on the last page of this letter and in a separate email with the filename: "CountyGHGAnalysisReport_Clark_20260123.pdf."

cities and towns because they allow shorter automobile trips and encourage walking, bicycling, and transit use thereby reducing per capita VMT.[15]

The Land Use Element, the Future Land Use Map, and the Rural Element should better protect working farms.

The Growth Management Act requires Clark County "*to assure the conservation of agricultural lands and to assure that the use of adjacent lands does not interfere with their continued use for the production of food or agricultural products.*[16] Clark County's BERK report documents that the 20-acre minimum lot size and non-agricultural uses allowed by the Agriculture (AG-20) comprehensive plan designation and zone fails to conserve agricultural land of long-term commercial significance because they allow "non-productive rural uses."[17] "Given onsite development or other non-productive rural uses (e.g. dwellings, manicured lawns associated with dwellings, etc.) there is a greater area zoned AG and a lesser area inventoried by [the Washington State Department of Agriculture] WSDA in agricultural use. WSDA inventoried acres make up between 15-27% of the AG 10 zone area [which was zoned AG-20 when the BERK report was written]."[18] The BERK report also found based on the Census of Agriculture that "1.5% of the [Clark County] farms are large, representing 72% of the total commodity outputs. … The loss of large farms corresponds to a loss in commodity totals. In 2007 dollars, the value of agriculture dropped from $62.3 million in 1997 to $52.7

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[15] Arthur C. Nelson, *Compact Development Reduces VMT: Evidence and Application for Planners—Comment on "Does Compact Development Make People Drive Less?"*, 83 JOURNAL OF THE AMERICAN PLANNING ASSOCIATION 36 pp. 36 – 38 (2017), DOI: 10.1080/01944363.2016.1246378 enclosed at the link on the last page of this letter with the filename: "Compact Development Reduces VMT Evidence and Application for Planners Comment on Does Compact Development Make People Drive Less.pdf." The Journal of the American Planning Association is peer-reviewed. Journal of the American Planning Association Instructions for authors webpage enclosed at the link on the last page of this letter with the filename: "JAPA Instructions for Authors June 2017.pdf."

[16] *King County v. Central Puget Sound Growth Management Hearings Bd. (Soccer Fields)*, 142 Wn.2d 543, 556, 14 P.3d 133, 140 (2000) emphasis in original.

[17] BERK Consulting, *Clark County Comprehensive Plan 2016 Update Planning for Growth 2015 – 2035: Clark County Agriculture and Forest Land Supplemental Mapping and Data Analysis – Issue Paper 9* p. 18 (June 23, 2016) last accessed on June 17, 2026, at https://www.clark.wa.gov/sites/default/files/dept/files/community-planning/2016-update/Plan%20Adoption/Final%20documents-maps/Issue%20Paper_9_Supplemental%20Resource%20Land%20Info_2016_0623_CLEAN.pdf enclosed at the link on the last page of this letter and in a separate email with the filename: "Issue Paper_9_Supplemental Resource Land Info_2016_0623_CLEAN.pdf."

[18] *Id.* at p. 18.

million in 2007, and again to $45.9 million in 2012."[19] Converting large farms to small farms and 20-acre estates with manicured lawns as the AG-20 zone allows will not conserve agricultural lands and encourage the agricultural economy as the GMA requires. Clark County should increase the minimum lot size to 40 acres and remove the nonagricultural uses from the comprehensive plan designation and zone.[20]

A transfer of development rights program cannot be used as an excuse to expand urban growth areas or dedesignate agricultural lands of long-term commercial significance.

A transfer of development rights program cannot be used as an excuse to expand urban growth areas or dedesignate agricultural lands of long-term commercial significance.[21] The GMA requires transfer of development rights programs to protect agricultural lands.[22] Interlocal agreements between the County and a city or cities also cannot be used as an excuse to expand urban growth areas or dedesignate agricultural lands of long-term commercial significance. That is because interlocal agreements must comply with state law.[23] Further, interlocal agreements cannot override state law.[24]

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[19] *Id.* at p. 6.
[20] Arthur Nelson, *Preserving Prime Farmland in the Face of Urbanization: Lessons from Oregon* 58 JOURNAL OF THE AMERICAN PLANNING ASSOCIATION 467, 471 – 74 (1992) enclosed at the link on the last page of this letter and in a separate email with the filename: "Preserving Prime Farmland in the Face of Urbanization Lessons from Oregon JAPA.pdf." The Journal of the American Planning Association is a peer-reviewed journal. Journal of the American Planning Association - Instructions for authors webpage pp. 3 – 4 of 9 enclosed at the link on the last page of this letter and in a separate email with the filename: "JAPA Instructions for Authors.pdf."
[21] *Orton Farms, LLC, et al. v. Pierce County*, Central Puget Sound Growth Management Hearings Board (CPSGMHB) Case No. 04-3-0007c, Final Decision and Order (Aug. 2, 2004) at pp. 36 – 37, 2004 WL 3275228 pp. *28 – 29 (footnote omitted); *Friends of Agriculture v. Grant County*, Eastern Washington Growth Management Hearings Board (EWGMHB) Case 05-1-0010, Final Decision and Order (March 14, 2006) at p. *10, 2006 WL 1370957 p. *7 quoting from *Orton Farms*; *Town of Friday Harbor, Fred R. Klein, John M. Campbell, Lynn Bahrych, et al. v. San Juan County*, Western Washington Growth Management Hearings Board (WWGMHB) Case No. 00-2-0062c, Order on Compliance and Invalidity Re: Resource Lands Redesignation(March 28, 2002), p. *5, 2002 WL 599680 p. *3 (March 28, 2002) ("we will start with the presumption of validity that would attach to any de-designation of resource lands, examine the record to ensure that it contains sufficient analysis that the appropriate GMA criteria (conservation imperative) was applied, and make our determination based upon the presumption of validity and the record under the clearly erroneous standard.")
[22] RCW 36.70A.060(5).
[23] *Exendine v. City of Sammamish*, 127 Wn. App. 574, 585 fn. 21, 113 P.3d 494, 499 (2005), as amended on denial of reconsideration (May 31, 2005), publication ordered (June 6, 2005).
[24] *Id.*

That transfer of development rights programs cannot justify urban growth area expansions is particularly true where there is no need to expand the urban growth areas as was documented above.

Comments on Chapter 3 Rural and Natural Resource Element

Reduce planned rural growth and capacity.

Not including rural population increases in the comprehensive plan and rural element would help reduce per capita VMT and greenhouse gas pollution.[25] Rural residents have substantially higher greenhouse gas emissions, particularly higher transport-related direct greenhouse gas emissions, than residents in the urban growth areas.[26] The transport-related direct emissions of rural residents are three times those in the inner city, and 1.5 times those in the suburbs.[27] So reducing rural growth will help protect the environment.

Thank you for considering our comments. If you require additional information, please contact me at telephone 206-343-0681 or email: tim@futurewise.org.

Very Truly Yours,



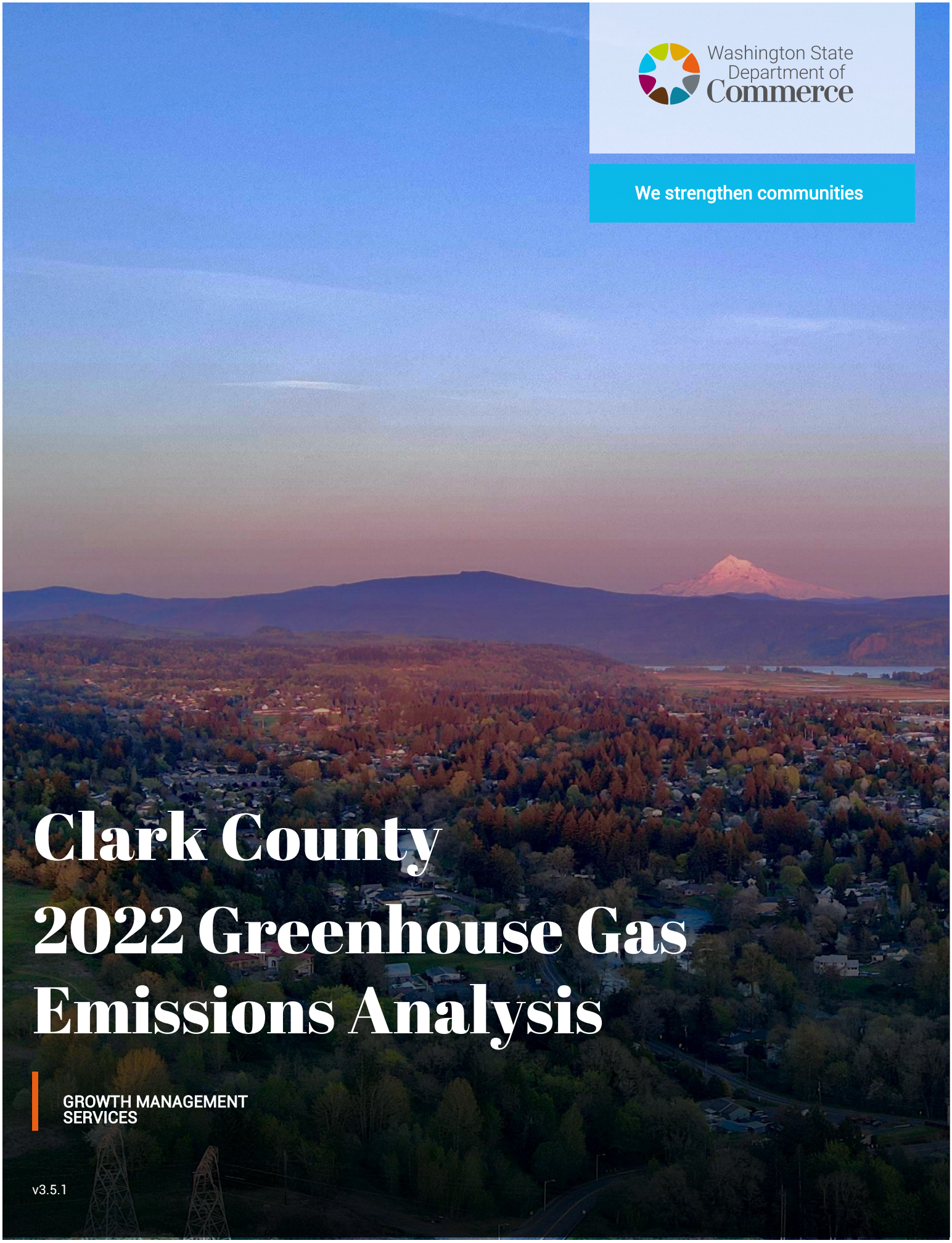
Tim Trohimovich, WSBA No. 22367
Director of Planning & Law

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[25] Arthur C. Nelson, *Compact Development Reduces VMT: Evidence and Application for Planners—Comment on "Does Compact Development Make People Drive Less?"*, 83 JOURNAL OF THE AMERICAN PLANNING ASSOCIATION 36 pp. 36 – 38 (2017), DOI: 10.1080/01944363.2016.1246378.
[26] Jeffrey Wilson, Jamie Spinney, Hugh Millward, Darren Scott, Anders Hayden, and Peter Tyedmers, *Blame the exurbs, not the suburbs: Exploring the distribution of greenhouse gas emissions within a city region* 62 ENERGY POLICY 1329, pp. 1334 – 35 (2013) enclosed at the link on the last page of this letter and in a separate email with the filename: "Blame_the_exurbs_not_the_suburbs_Explori.pdf." Energy Policy is a peer reviewed journal. Energy Policy Guide for authors webpage p. *14 last accessed on Feb. 3, 2026, at: https://www.sciencedirect.com/journal/energy-policy/publish/guide-for-authors and enclosed at the link on the last page of this letter and in a separate email with the filename: "Guide for authors - Energy Policy.pdf."
[27] Jeffrey Wilson, Jamie Spinney, Hugh Millward, Darren Scott, Anders Hayden, and Peter Tyedmers, *Blame the exurbs, not the suburbs: Exploring the distribution of greenhouse gas emissions within a city region* 62 ENERGY POLICY 1329, p. 1335 (2013).

Enclosures at this link:

https://futurewiseorg.sharepoint.com/:f:/g/IgAIkOZVzGs9QYtZ5F3NHbVpAfX-lUuvva5bsIfPoIDLFgA?e=ynGxNB



Washington State Department of Commerce

We strengthen communities

Clark County 2022 Greenhouse Gas Emissions Analysis

GROWTH MANAGEMENT SERVICES

v3.5.1

Acknowledgements[1]

Washington State Department of Commerce
Sarah Fox, Climate & Ecosystem Section Manager

Michael Burnham, Climate Policy Manager

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WSP

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The information, analyses, and recommendations presented in this report are based on the context, data, and resources available at the time of its development. Changes in circumstances, additional information, or new developments may affect the relevance or accuracy of the content. While every effort has been made to ensure the accuracy and reliability of the information provided, readers are encouraged to consider changes in conditions (for example, legal or policy framework) when making decisions.

This report incorporates revisions to the July 2025 version. Updates reflect improved data inputs to enhance accuracy and consistency.

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Executive Summary

To better understand current and future greenhouse gas (GHG) emissions in Washington and support local comprehensive planning, the Washington Department of Commerce (Commerce) funded an 11-county GHG emissions inventory and scenario planning effort. HB 1181, signed into law in 2023, requires Washington cities and counties to incorporate a Climate Element into Comprehensive Plans to build resilience and reduce GHG emissions. For 11 counties and the cities within, development of a greenhouse gas emissions sub-element is mandatory for inclusion in the jurisdiction's next Comprehensive Plan update. This GHG analysis effort aims to support local comprehensive planning, as identifying current and future emissions is a critical step in understanding where the state's largest sources of emissions are occurring and where there are opportunities for emissions reduction. This report provides a summary of 2022 communitywide and county government operations emissions for Clark County, as well as projected future emissions and GHG emission reduction strategies. Clark County's communitywide and operational emissions were quantified for the 2022 calendar year, representing the most recent year with complete data at the time of this study.

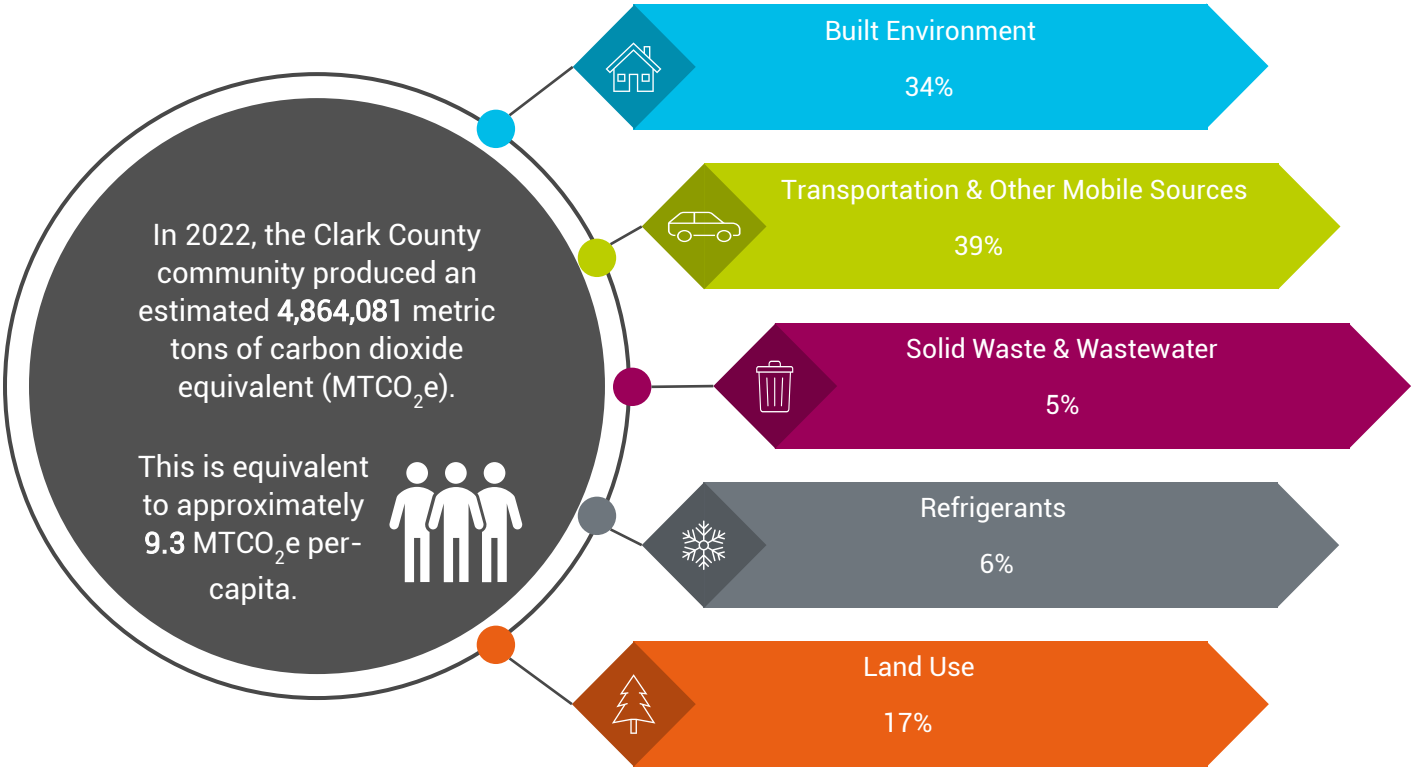
This inventory reports both the county's total emissions (includes direct and indirect emissions from industry, agriculture, and other sectors) and its "core" emissions (includes sectors over which county governments often have the most influence through local policy mechanisms such as local codes/regulations). We recommend that the county use its core emissions as a starting point for shaping comprehensive plan policies. We also recommend that the county consider policies that address emissions from non-core sectors to support co-benefits such as clean air and water, improve resilience, and provide beneficial opportunities such as local food systems.

2022 Greenhouse Gas Emissions Profile

Communitywide

The communitywide emissions inventory quantifies emissions produced by activity from county residents, businesses, schools, and visitors, including from buildings, transportation, land use, and solid waste generation and disposal. In 2022, the Clark County community produced an estimated total of 4,864,081 metric tons of carbon dioxide equivalent ($MTCO_2e$), which equates to approximately 9.3 $MTCO_2e$ per capita. Figure 1 shows the breakdown of total 2022 communitywide emissions, including emissions from the built environment, transportation, solid waste and wastewater treatment, refrigerant usage, and land use.

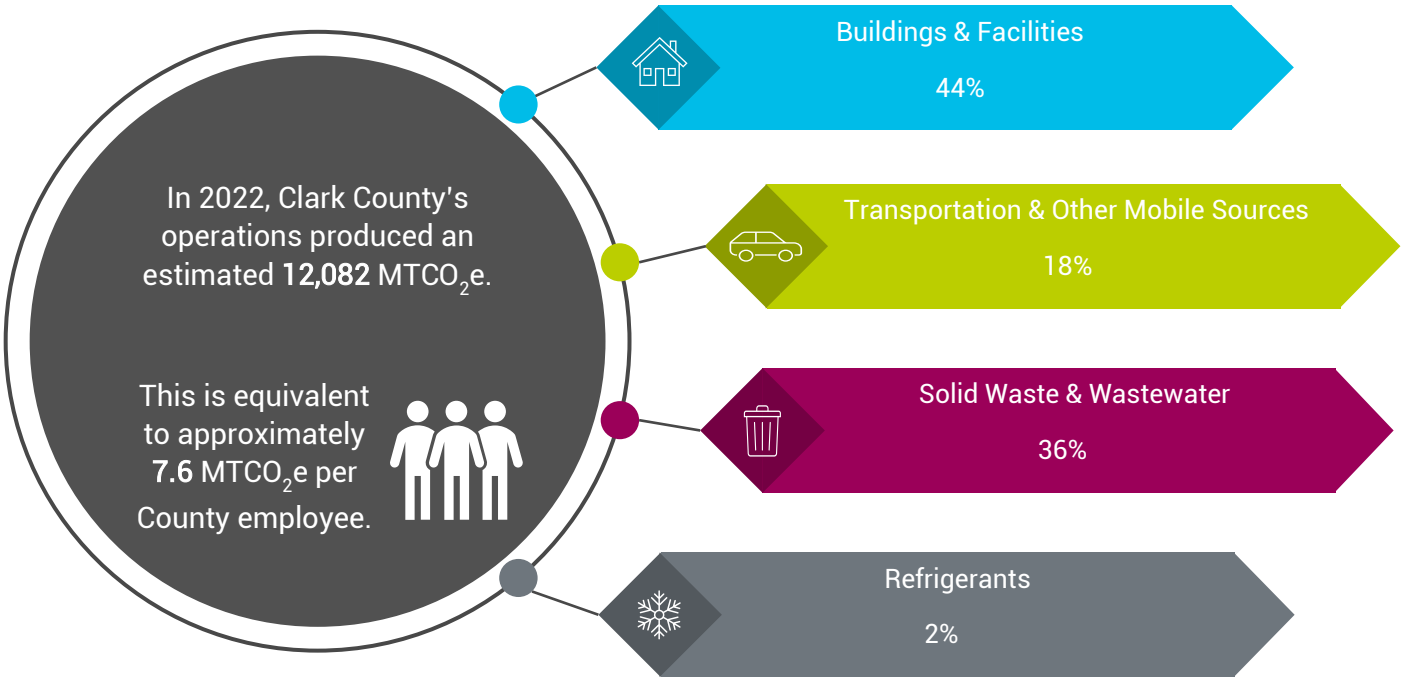
FIGURE 1. 2022 COMMUNITYWIDE GHG EMISSIONS PROFILE BY SOURCE.



County Operations

The county operations emissions inventory reports emissions that are produced by county government activities and facilities, including from county facilities, fleet vehicles, employee commuting, and waste generation and disposal. In 2022, Clark County's operations produced an estimated 12,082 $MTCO_2e$. Figure 2 shows the breakdown of 2022 county operations emissions, including emissions from county facilities, transportation (fleet vehicles, employee commuting, and business travel), solid waste and wastewater treatment, and refrigerant usage.

FIGURE 2. 2022 COUNTY OPERATIONS GHG EMISSIONS PROFILE BY SOURCE.

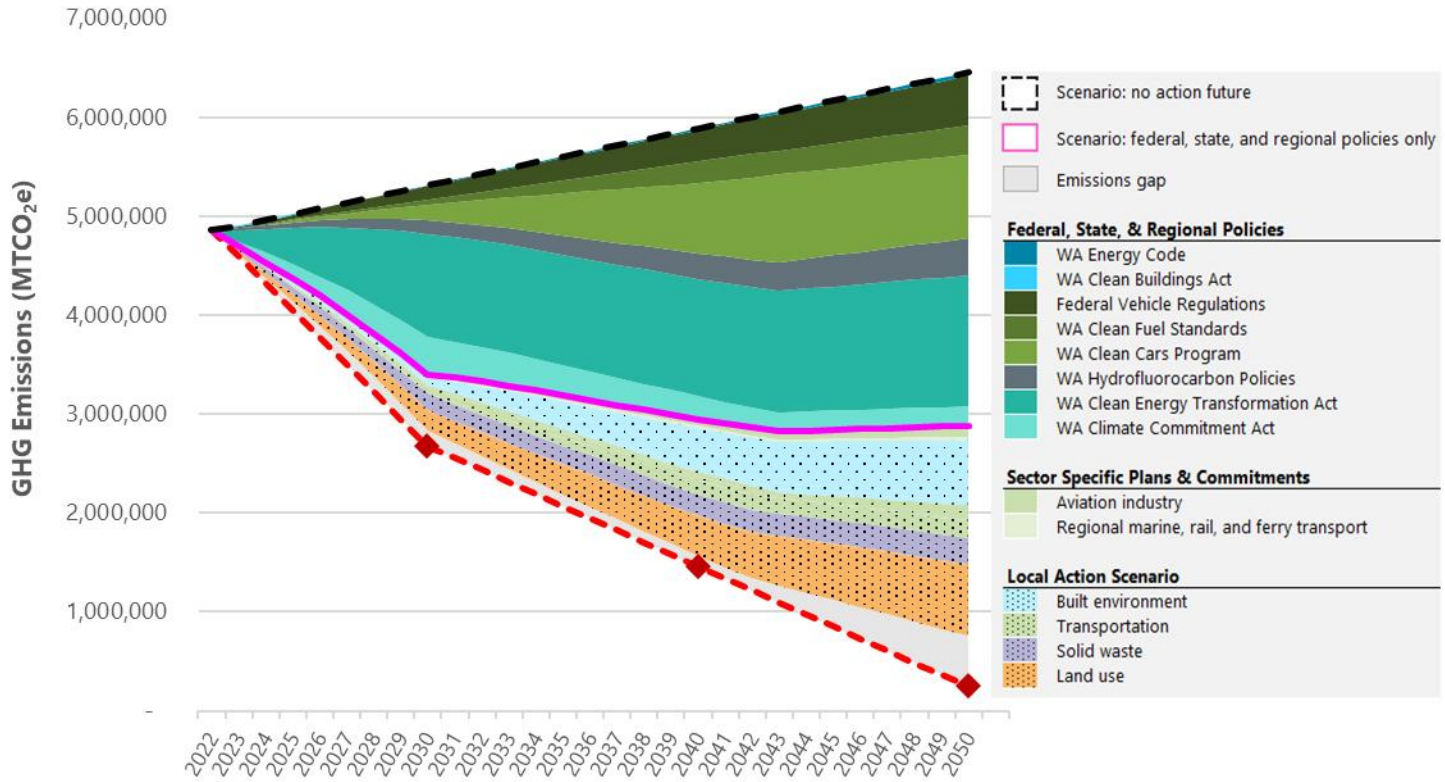


Future Emissions Projections & Local Strategies

A forecasting analysis of Clark County's communitywide emissions from 2022 to 2050 revealed the following total emissions projections under three scenarios compared to Washington state greenhouse gas emission reduction targets (45% by 2030, 70% by 2040, and 95% by 2050, compared to a 1990 baseline):

- Business-as-usual (BAU), which assumes no action is taken to reduce GHG emissions. Under this scenario, Clark County's emissions will grow 33% by 2050 (compared to a 1990 baseline), as depicted by the dotted black line in Figure 3.
- Adjusted business-as-usual (ABAU), which models estimated emissions reductions from existing federal, state, and regional policies. This scenario estimates a 41% reduction in communitywide emissions by 2050 (compared to a 1990 baseline), as depicted by the pink line in Figure 3.
- Local action scenario, which models estimated emission reductions from local climate actions such as reducing building energy consumption or transitioning to electric vehicles: Combined with the ABAU, this scenario estimates an 88% total reduction in communitywide emissions by 2050 (compared to a 1990 baseline), as shown by the local action scenario reductions in Figure 3.

FIGURE 3. FORECASTED GHG EMISSIONS AND REDUCTIONS ($MTCO_2E$).



These analyses of current and projected future GHG emissions provide insight into local policy options for reducing GHG emissions in Clark County. As presented in the local action scenario, key GHG emission reduction strategies for focus in Clark County's comprehensive plan update include:

- Reduce energy consumption in new and existing residential and commercial buildings through: 1) supporting clean building energy sources and 2) energy-efficient building design and retrofits. Local action to transition to renewable building energy sources would reduce Clark County's built environment emissions, which made up 34% of 2022 communitywide emissions.
- Reduce passenger vehicle travel within the county, including through changes to land use, transportation infrastructure (transit, walking, bicycling), and commuting options/modes. A reduction in passenger VMT would reduce Clark County's communitywide on-road emissions from passenger vehicles, which made up 21% of 2022 emissions.
- Facilitate the transition to electric vehicles through expansion of reliable EV charging infrastructure and public education on options and available incentives/rebates. Local action to support transitioning passenger and freight vehicles to electric would reduce Clark County's passenger and freight vehicle on-road emissions, which made up 30% of 2022 communitywide emissions.
- Limit tree loss and support low-carbon land practices such as sustainable forestry, agriculture, and livestock management. Reducing tree loss emissions and emissions from agricultural practices in Clark County would reduce land use emissions, which made up 17% of 2022 communitywide emissions.
- Work with local industries to support transition to low-carbon industrial processes, including for high-carbon industries such as semiconductor device manufacturing and operating paper mills. These industrial process emissions made up 2% of Clark County's 2022 communitywide emissions.

Introduction

To better understand current and future greenhouse gas (GHG) emissions in Washington and support local comprehensive planning, WA Department of Commerce (Commerce) funded an 11-county GHG emissions inventory and scenario planning effort. HB 1181, signed into law in 2023, requires Washington cities and counties to incorporate a Climate Element into Comprehensive Plans to build resilience and reduce GHG emissions. For 11 counties and the cities within, development of a greenhouse gas emissions sub-element is mandatory for inclusion in the jurisdiction's next Comprehensive Plan update. This GHG analysis effort aims to support local comprehensive planning for these counties, as identifying current and future emissions is a critical step in understanding where the state's largest sources of emissions are occurring and where there are opportunities for emissions reduction. This report provides a summary of 2022 communitywide and county government operations emissions for Clark County, as well as projected future emissions and GHG emission reduction strategies.[2]

Methodology

In determining the methodology used to complete Clark County's GHG analyses, the project team used the following guiding principles:

- Replicability and transparency, to ensure that analyses can be conducted in future years.
- Consistency, both across counties and with past county GHG analyses, where applicable.
- Accuracy, including through inclusion of all relevant sectors, use of locally specific data, and alignment with industry best practices.

GHG Emissions Inventories

The following protocols were referenced to complete the GHG emission inventories:

- Clark County's communitywide inventory was performed using guidance from both ICLEI's U.S. Community Protocol for Accounting and Reporting of GHG Emissions (USCP)[3] and The Greenhouse Gas Protocol's Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC)[4]. These protocols are the industry standards for quantifying GHG emissions from community activities.[5]
- Clark County's operational inventory was performed using guidance from ICLEI's Local Government Operations Protocol for the Quantification and Reporting of GHG Emissions Inventories (LGOP).[6] This protocol outlines a standardized method for local governments to estimate operational emissions.

Clark County's communitywide and operational emissions were quantified for the 2022 calendar year, chosen as the most recent year with complete data at the time of this study. All analyses were performed in Microsoft Excel.

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[2] The GHG emissions estimates shown in this report are intended to support development of Clark County's Climate Element. The county may reference additional and/or more locally-specific analyses to support a comprehensive understanding of its GHG emissions context.
[3] U.S. Community Protocol | ICLEI USA
[4] Global Protocol for Community-Scale GHG Inventories (GPC) | GHG Protocol.
[5] These two protocols have different geographic specificities (e.g., the GPC is more global, while the U.S. Community Protocol has more of a U.S. focus). Both share the same basic GHG accounting principles.
[6] Local Government Operations (LGO) Protocol | ICLEI USA

Emissions Sources

The GHG emissions inventories, forecast, and scenario analysis included emissions sources listed in Table 1, as applicable. These sources are recommended by protocols and aligned with industry best practices.

The table below also identifies communitywide "core emissions" sources, which are emissions produced by sectors most commonly included in community greenhouse gas inventories and over which county governments often have the most influence (e.g., through local policy mechanisms such as local codes/regulations). Core emissions included in this inventory, indicated in **bold** in the table below, include emissions from electricity, natural gas, on-road vehicles, solid waste generation and disposal, and wastewater treatment processes. While agriculture, tree loss, and some other emissions sources are not included in the core emissions scenario, Commerce still strongly encourages local jurisdictions to consider comprehensive plan policies to address emissions from these sources. Such policies will support co-benefits such as clean air and water, improve resilience, and provide beneficial opportunities such as local food systems.

TABLE 1. EMISSIONS SOURCES FOR THE 2022 COMMUNITYWIDE AND COUNTY OPERATIONS GHG ANALYSES.

Sector	Communitywide	County Operations
Buildings	**Electricity** **Natural gas** Propane Fuel oil Industrial processes	Electricity Natural gas Propane Fuel oil
Transportation	**On-road vehicles** Off-road equipment Aviation	County fleet vehicles & equipment County employee commute County business travel
Solid Waste	**Landfilled waste generation & disposal** **Compost generation & disposal**	Landfilled waste generation & disposal Compost generation & disposal County landfills
Wastewater	**Treatment processes** **Septic systems**	Treatment processes
Land Use	Agriculture Forests & land use change	N/A
Refrigerants	Refrigerants	Refrigerants

Detailed methodologies and data considerations for each emissions source are provided in Appendix A.

Forecast & Scenario Planning

The interactive communitywide GHG emissions forecasting and scenario planning analysis estimated emissions from 2022 to 2050 under the following three scenarios:

- Business-as-usual (BAU), which assumes no action is taken to reduce GHG emissions.
- Adjusted business-as-usual (ABAU), which models estimated emissions reductions from existing federal, state, and regional policies.
- Additional local action needed to achieve state GHG emission reduction targets.

This analysis was conducted in a user-friendly tool based in Microsoft Excel, which allows for custom user-defined inputs and real-time scenario planning to inform GHG emission reduction policy development.

Local Policy Options

Outputs from Clark County's GHG emissions inventories, forecast, and scenario analysis supported development of county-specific local policy options. These options were developed through consultation with county staff and included detailed review of county emissions sources.

GHG Emissions Inventory Findings

Communitywide Inventory

In 2022, the Clark County community produced an estimated 4,864,081 $MTCO_2e$, 2,993,171 $MTCO_2e$ of which are from core emissions sources. This total equates to approximately 9.3 and 5.7 $MTCO_2e$ per-capita for the total and core emissions sources, respectively. Accounting for all emissions sources, the community's largest sources of emissions were from transportation & other mobile sources, contributing 39% of total emissions, and built environment (buildings) contributing 34%. Figure 4 and Table 2 summarize 2022 communitywide emissions by sector and source.

Note that the on-road vehicle emissions listed in Figure 4 and Table 2 utilize vehicle miles traveled (VMT) data from WSDOT's Highway Performance Monitoring System (HPMS). For additional context, the "Transportation" section on page 15 discusses alternative methods for estimating VMT in Clark County.

FIGURE 4. 2022 COMMUNITYWIDE EMISSIONS PROFILE ($MTCO_2E$).

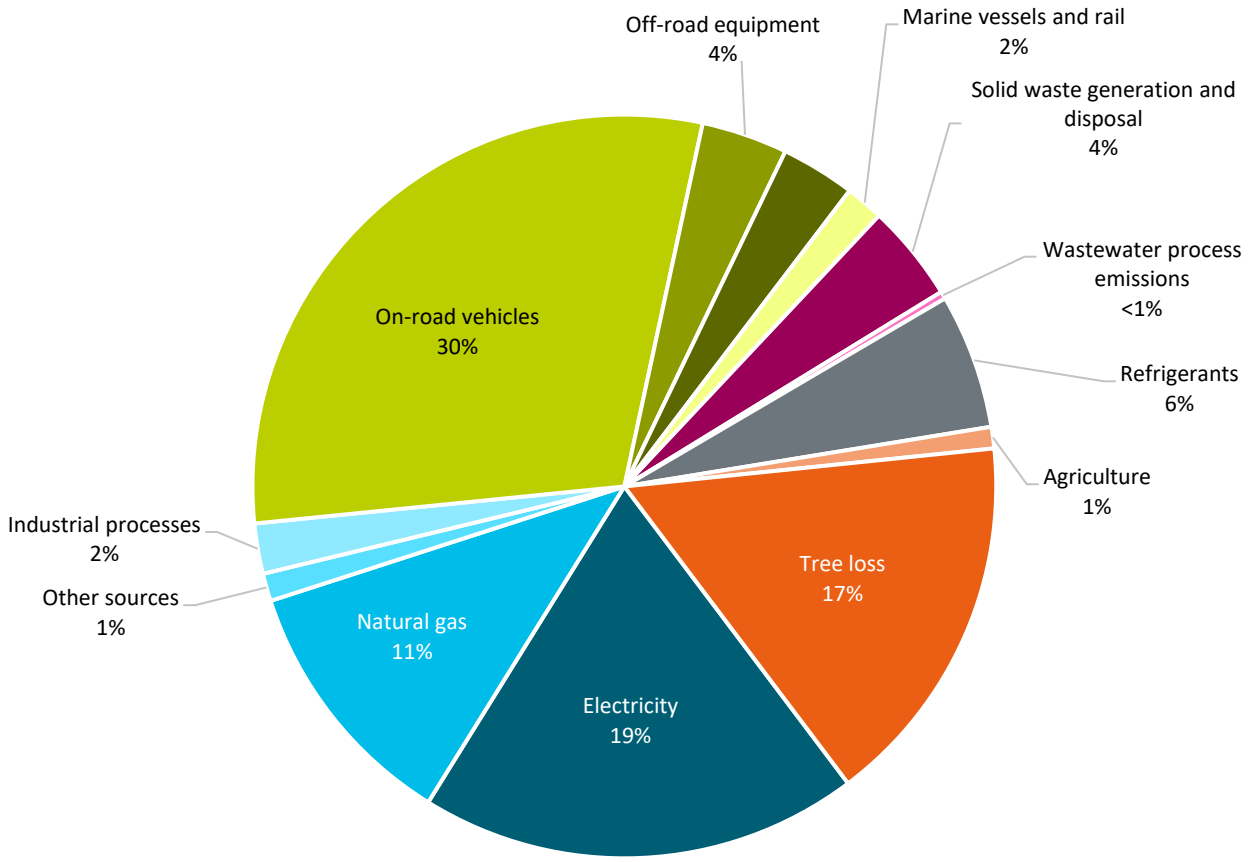


TABLE 2. TOTAL AND PER-CAPITA COMMUNITYWIDE GHG EMISSIONS, BY SECTOR ($MTCO_2E$ AND %).

GHG Emissions Sector	Total Emissions ($MTCO_2e$)	Per-capita Emissions ($MTCO_2e$)	Percent of Emissions (%)
Built Environment			
Electricity	**930,242**	**1.8**	**19%**
Residential	529,007	1.0	11%
Commercial	258,664	0.5	5%
Industrial	142,571	0.3	3%
Natural Gas	**543,500**	**1.0**	**11%**
Residential	288,896	0.6	6%
Commercial	237,375	0.5	5%
Industrial	17,229	<0.1	<1%
Propane	**28,977**	**<0.1**	**<1%**
Residential	13,633	<0.1	<1%
Commercial	15,344	<0.1	<1%
Fuel Oil	**29,594**	**<0.1**	**<1%**
Residential	4,634	<0.1	<1%
Commercial	24,960	<0.1	<1%
Industrial Processes	**106,281**	**0.2**	**2%**
Transportation & Other Mobile Sources			
On-Road Vehicles	**1,457,997**	**2.8**	**30%**
Passenger vehicles	1,026,060	2.0	21%
Freight & service vehicles	421,963	0.8	9%
Public transit	9,974	<0.1	<1%
Off-Road Equipment	**182,173**	**0.3**	**4%**
Aviation	**157,069**	**0.3**	**3%**
Marine & Rail	**80,302**	**0.2**	**2%**
Solid Waste & Wastewater			
Solid Waste Generation & Disposal	**205,616**	**0.4**	**4%**
Landfill	204,124	0.4	4%
Compost	1,492	<0.1	<1%
Wastewater Processes	**15,617**	**<0.1**	**<1%**
Refrigerants			
Refrigerants	**285,715**	**0.5**	**6%**
Land Use			
Agriculture	**45,476**	**<0.1**	**<1%**
Tree Cover Loss	**795,522**	**1.5**	**16%**
Total Emissions	**4,864,081**	**9.3**	**100%**
Core Emissions	*2,993,171*	*5.7*	*62%*

TABLE 2. CORE COMMUNITYWIDE AND PER-CAPITA GHG EMISSIONS, BY SECTOR ($MTCO_2E$ AND %).

GHG Emissions Sector	Total Emissions ($MTCO_2e$)	Per-capita Emissions ($MTCO_2e$)	Percent of Emissions (%)
Built Environment			
Electricity	787,671	1.5	26%
Residential	529,007	1.0	18%
Commercial	258,664	0.5	9%
Natural Gas	526,271	1.0	18%
Residential	288,896	0.6	10%
Commercial	237,375	0.5	8%
Transportation & Other Mobile Sources			
On-Road Vehicles	1,457,997	2.8	49%
Passenger vehicles	1,026,060	2.0	34%
Freight & service vehicles	421,963	0.8	14%
Public transit	9,974	<0.1	<1%
Solid Waste & Wastewater			
Solid Waste Generation & Disposal	205,616	0.4	7%
Landfill	204,124	0.4	7%
Compost	1,492	<0.1	<1%
Wastewater Processes	15,617	<0.1	<1%
Core Emissions	2,993,171	5.7	100%

The sections below provide a more detailed summary of GHG emissions inventory findings within each sector. Values are presented using the total emissions (i.e., not "core" emissions) framework.

Built Environment

The built environment sector made up 34% of Clark County's 2022 total communitywide emissions, contributing 1,638,594 $MTCO_2e$. This sector includes emissions from the use of electricity, natural gas, propane, and fuel oil to heat, cool, and power buildings, as well as direct emissions from industrial processes within the county.

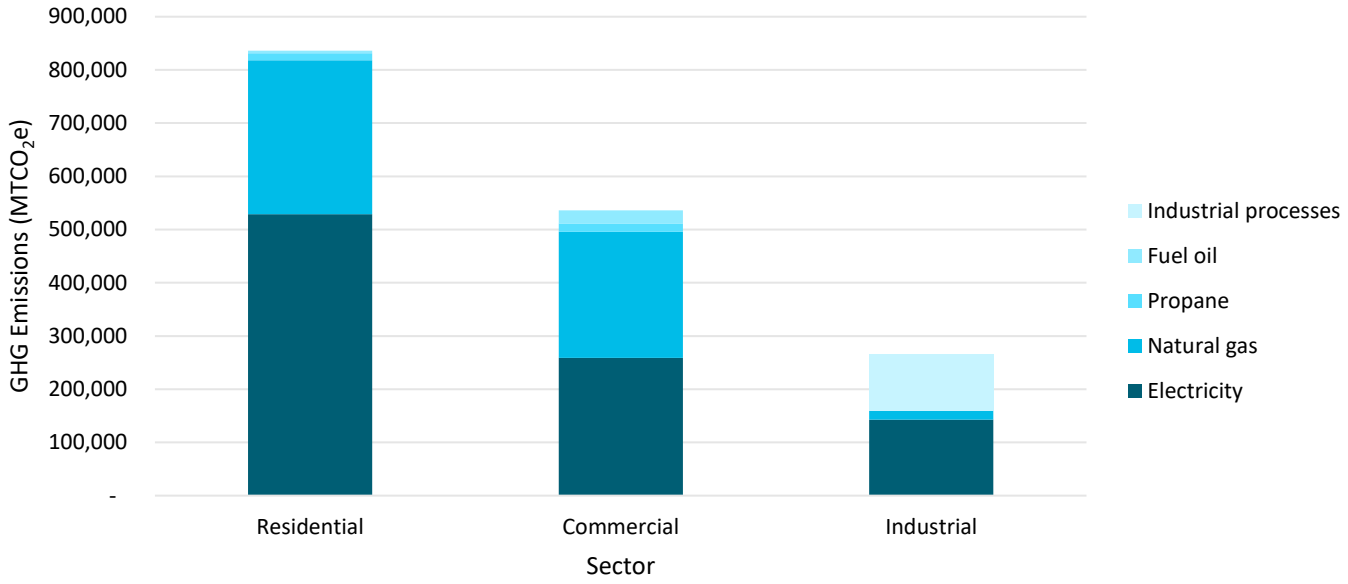


Figure 5 below summarizes Clark County's 2022 emissions from the built environment, by sector and source. An estimated 19% and 11% of Clark County's total communitywide emissions stemmed from electricity and natural gas consumption, respectively. Propane and fuel oil consumption contributed <1% and <1%, respectively, and 2% of communitywide emissions were produced by industrial processes within Clark County.

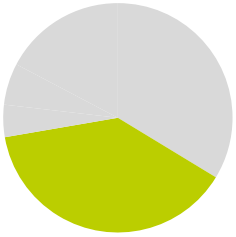
Emissions from electricity were calculated using utility-specific emission factors sourced from the WA Department of Ecology. For informational purposes, emissions from electricity were also calculated using the regional electric grid emissions factor, sourced from the EPA Emissions & Generation Resource Integrated

Database (eGRID). When calculated using this location-based method, Clark County's electricity emissions were approximately 1,487,170 $MTCO_2e$, compared to 930,242 $MTCO_2e$ when estimated using a utility-specific approach.

FIGURE 5. BUILT ENVIRONMENT GHG EMISSIONS, BY SECTOR AND SOURCE.

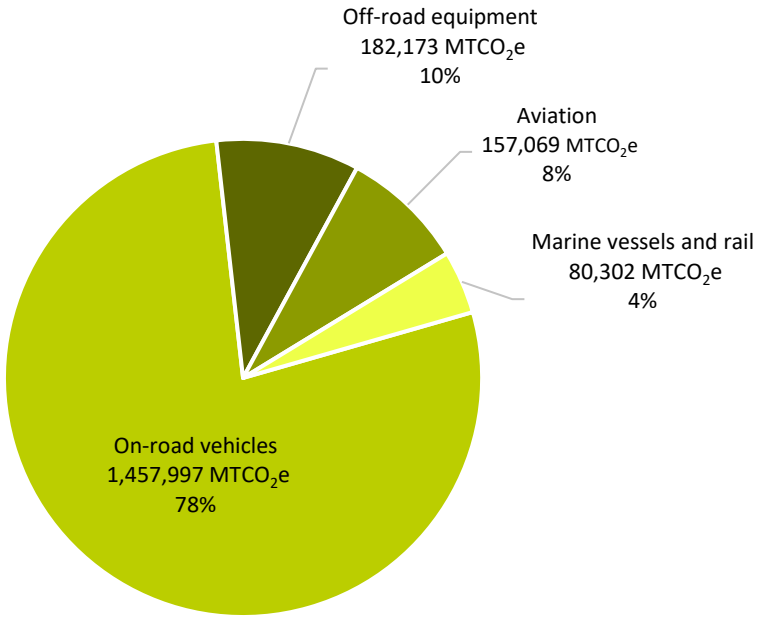


Transportation



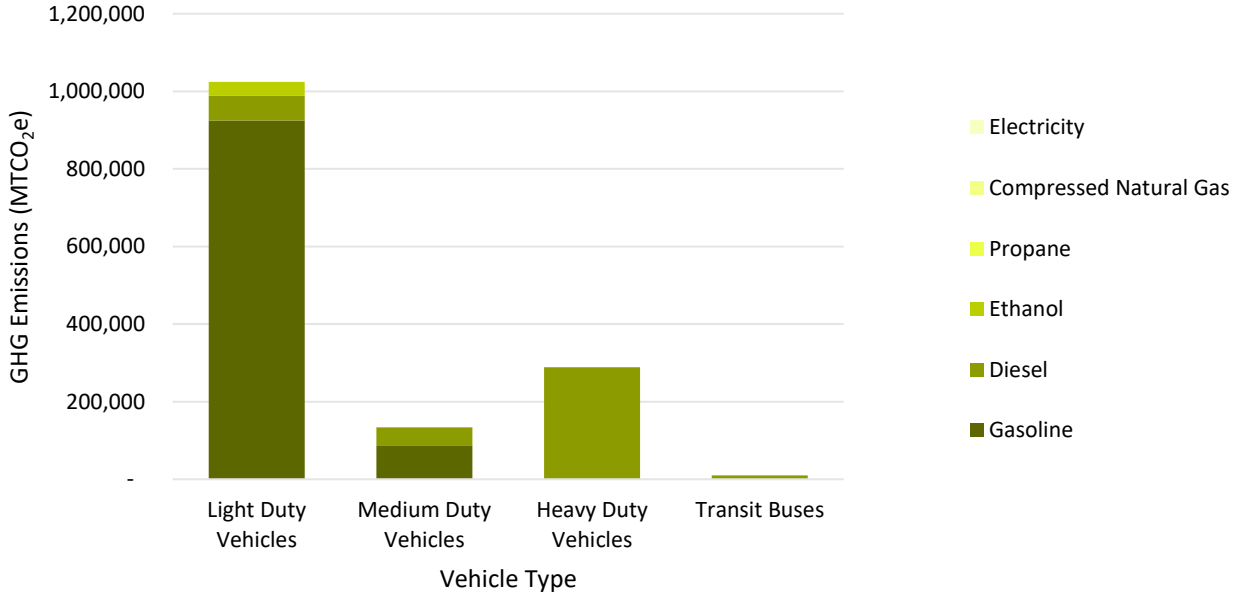
The transportation sector made up 39% of Clark County's 2022 total communitywide emissions, emitting an estimated 1,877,541 $MTCO_2e$. This sector includes emissions from the use of on-road vehicles and off-road equipment, as well as emissions from marine, rail, and air travel, shown in Figure 6 below.

FIGURE 6. TRANSPORTATION EMISSIONS, BY SOURCE.



On-road vehicle emissions include those from passenger vehicles, freight and service trucks, and transit vehicles within the county boundary, and made up 78% of Clark County's 2022 total transportation emissions. On-road emissions by vehicle and fuel type are shown in Figure 7.

FIGURE 7. ON-ROAD TRANSPORTATION EMISSIONS, BY VEHICLE AND FUEL TYPE.



On-Road Vehicles

The GHG emissions inventory presented in this report is consistent with state law requirements to use data provided by Washington State Department of Transportation (WSDOT) and uses estimates of total vehicle miles traveled (VMT) within the Clark County geographic boundary. This estimate sums the vehicle miles driven on all public roadways within the county. The total VMT is then divided by the county's population to calculate a 'VMT per capita' value. In this context, "per capita" refers to the resident population of Clark County. As a result, the 'VMT per capita' value represents the total segment-level VMT within the county relative to its residential population, regardless of whether the miles were generated by residents, visitors, or pass-through traffic, or the purpose of the travel. Based on this approach, we estimate the per-capita VMT in Clark County in 2022 to be approximately 14 vehicle miles per day.

It is important to note that this reported 'VMT per capita' metric from both WSDOT and the regional travel demand model is not the same as 'VMT generated per resident.' It has limited value in explaining individual travel behavior and does not account for travel behavior outside of the county, such as trips made by residents and employees commuting to or from Clark County for work.

To better understand the travel behavior of Clark County residents and employees, we have used a third-party VMT data source that provides home-based VMT estimates. Home-based VMT refers to the total number of miles driven by automobile trips originating from a person's home. This data allows us to answer specific questions about community travel patterns, such as, "How many vehicle miles are driven to and from work each day by employees working in the county?" Additionally, this data can be used to develop targeted VMT reduction strategies, such as reducing single-occupancy vehicle commutes for large employers. For Clark County in 2022, this data source provides the following average daily VMT metrics:

23 home-based VMT per resident



Home-Based VMT per Resident

14 home-based work VMT per employee



Home-Based Work (HBW) VMT

Home-based VMT measures the amount of vehicle-miles-traveled for all trips that either start or end at home by a resident living in the county.

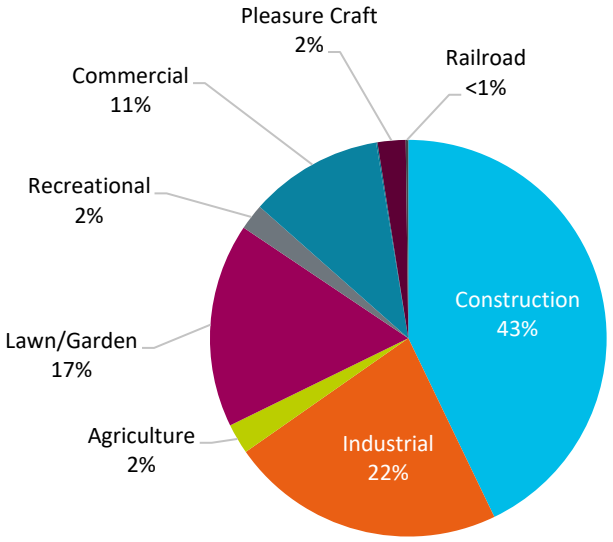
Home-based work (HBW) VMT measures the vehicle-miles-traveled for commute trips (trip either starts/ends at home and starts/ends at work) by an employee working in the county.

Offroad Vehicles & Equipment

In addition to on-road vehicles, emissions from the following off-road equipment categories were included in this inventory: recreational, construction, industrial, lawn/garden, agriculture, commercial, logging, airport support, oil field, pleasure craft, and railroad. Off-road vehicles and equipment produced 182,173 $MTCO_2e$,

making up 4% of communitywide emissions. The largest source of off-road emissions was construction, producing 43% of all off-road vehicle and equipment emissions.

FIGURE 8. OFF-ROAD EMISSIONS, BY SECTOR.



Solid Waste & Wastewater

The solid waste and wastewater sector made up 5% of Clark County's total 2022 communitywide emissions, contributing an estimated 221,233 $MTCO_2e$. This sector includes emissions from the generation and disposal of solid waste and commercially processed compost (if available), as well as the treatment of wastewater produced within Clark County.

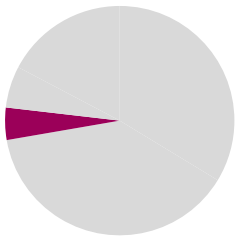
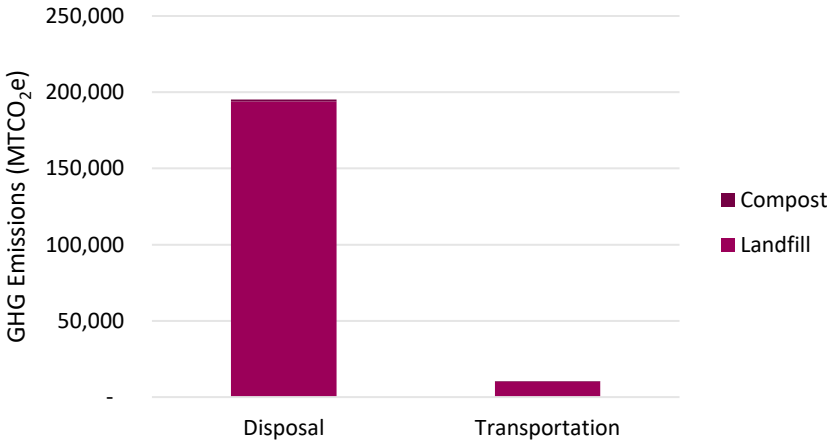


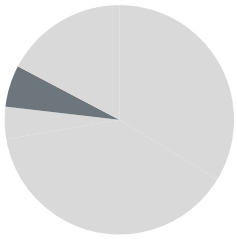
FIGURE 9. EMISSIONS FROM SOLID WASTE GENERATION, BY ACTIVITY AND WASTE TYPE.



Emissions from wastewater are generated by the biological processing of organic wastewater at treatment facilities, as well as from septic systems within the community. In 2022, emissions from wastewater made up <1% of total communitywide emissions. Wastewater treatment plants within Clark County also produce emissions through energy used to power wastewater treatment processes; these emissions are accounted for in the commercial energy sector to avoid double-counting between sectors.

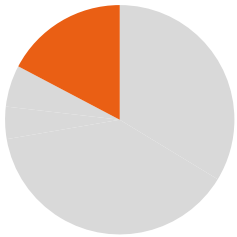
Refrigerants

Refrigerant emissions accounted for 6% of Clark County's 2022 total communitywide emissions, contributing an estimated 285,715 $MTCO_2e$. The refrigerant sector includes emissions from the use and leakage of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and CO_2 from ozone depleting substances (ODSs). Due to local data limitations, refrigerants emissions in this inventory are downscaled from national-level data to the county level based on population.



Land Use

Land use emissions made up 17% of Clark County's 2022 total communitywide emissions, contributing approximately 840,998 $MTCO_2e$. The land use sector includes emissions from agricultural activities such as soil management, digestive processes in livestock (enteric fermentation), and manure management, in addition to emissions from land use changes and tree loss. Clark County had approximately 22,009 acres of agricultural cropland in 2022.



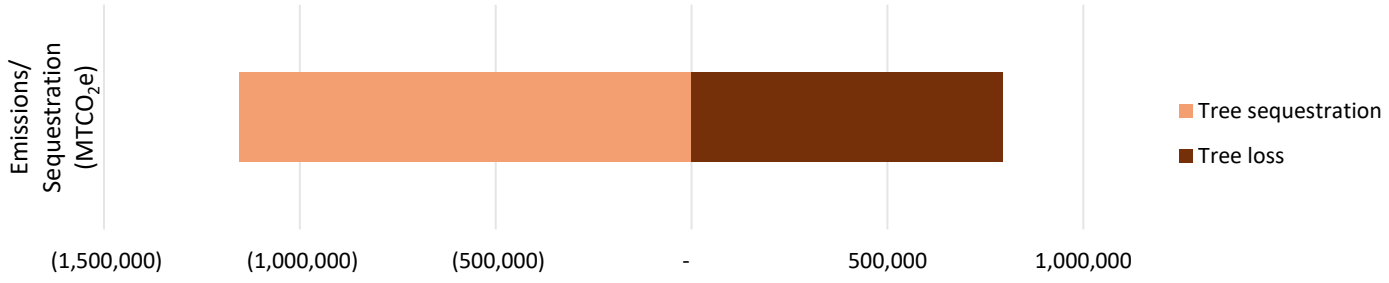
In 2022, the largest emitter of agricultural emissions in Clark County was beef cows, producing 47% of agriculture emissions.

Emissions from land use also include emissions from tree cover loss within Clark County, stemming from forest management and activities that result in conversion of tree-covered land into settlements, grasslands, or other non-forested land types. In 2022, changes to tree cover resulted in the generation of approximately 795,522 $MTCO_2e$. Note that emissions from tree loss consider emissions from all lands within the county's boundary, regardless of ownership, which can include state and federally owned and managed lands.

Tree Carbon Sequestration

Trees and forests in Clark County sequestered approximately 1,156,221 $MTCO_2e$ from the atmosphere in 2022. Carbon sequestration refers to the removal of carbon dioxide from the atmosphere. This sequestration estimate is derived from remote sensing data and accounts for tree characteristics, including tree types, age, and health. Figure 10 below compares estimated GHG emissions from tree cover loss to GHG removals from tree carbon sequestration in 2022. Causes of tree loss include conversion from forest to other land uses; deforestation/harvesting; reduction in urban tree canopy; and degradation from insects, fire, and diseases. Emissions from tree cover loss are not netted with sequestration in this inventory to present a complete picture of gross GHG emissions and to support identification of reduction opportunities. Note that these tree loss emissions estimates do not consider loss of future carbon sequestration potential. For additional information regarding emissions from tree cover loss and carbon sequestration in Clark County, see Appendix D.

FIGURE 10. TREE COVER GHG EMISSIONS AND SEQUESTRATION.



County Operations Inventory

The county operations emissions inventory summarizes GHG emissions produced by county government activities, including from county-owned and operated facilities. In 2022, Clark County's operations produced an estimated 12,082 $MTCO_2e$. The county's largest sources of emissions occurred from built environment, contributing 44% of total county operations emissions, and solid waste & wastewater, contributing 36%. County operations emissions in 2022 made up 0.25% of Clark County's 2022 communitywide emissions. Figure 11 and Table 3 depicts Clark County's 2022 operational emissions by sector and source. Any values marked as N/A indicate insufficient data availability for that emissions source

FIGURE 11. COUNTY OPERATIONS EMISSIONS PROFILE ($MTCO_2E$).

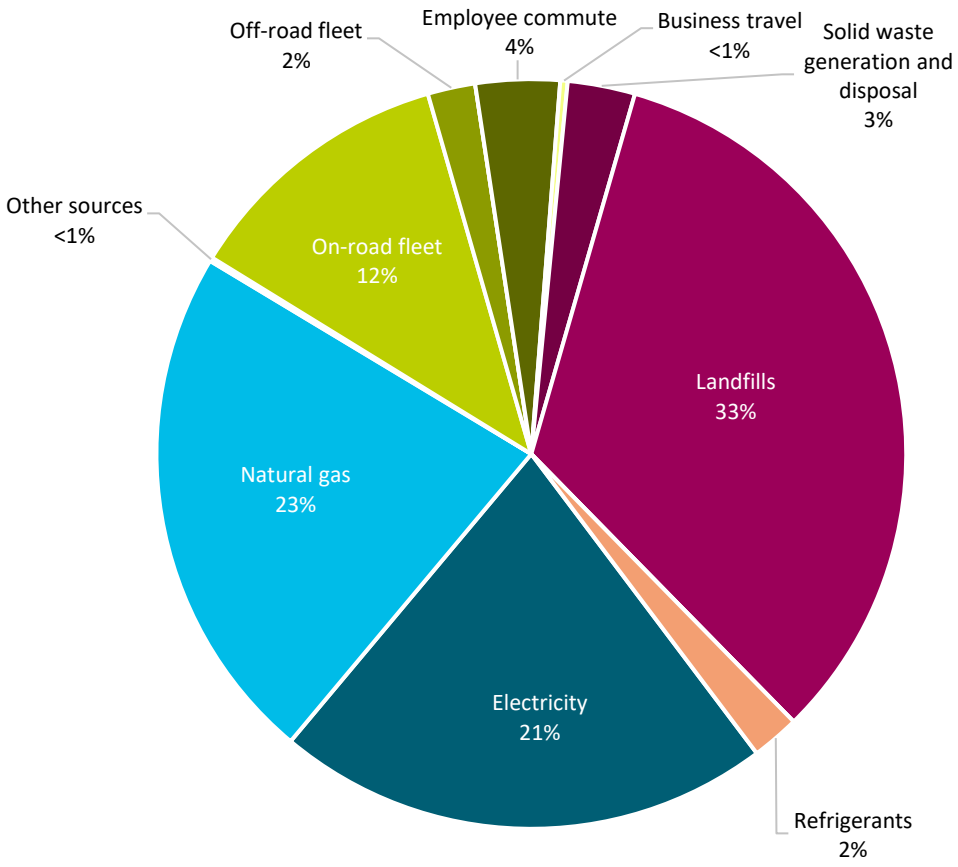


TABLE 3. 2022 TOTAL AND PER-EMPLOYEE COUNTY OPERATIONS GHG EMISSIONS, BY SECTOR ($MTCO_2E$ AND %).

GHG Emissions Sector	Total Emissions ($MTCO_2e$)	Per-employee Emissions ($MTCO_2e$)	Percent of Emissions (%)
Built Environment			
Electricity	2,583	1.6	21%
Natural Gas	2,720	1.7	23%
Propane	N/A	N/A	0%
Fuel Oil	N/A	N/A	0%
Power Generation	20	<0.1	<.1%
Transportation & Other Mobile Sources			
Fleet Vehicles & Equipment	1,670	1.0	14%
On-road fleet vehicles	1,422	0.9	12%
Off-road fleet equipment	248	0.2	2%
Employee Commute	439	0.3	4%
Business Travel	38	<0.1	<.1%
Solid Waste & Wastewater			
Solid Waste Generation & Disposal	4,362	2.7	36%
Landfilled waste	324	0.2	3%
Composted waste	27	<0.1	<.1%
County-owned landfills	4,010	2.5	33%
Wastewater Processes	N/A	N/A	0%
Refrigerants			
Refrigerants	249	0.2	2%
Stationary refrigerants	249	0.2	2%
Mobile refrigerants	N/A	N/A	0%
Total Emissions	12,082	7.6	100%

Built Environment

The built environment sector, which includes emissions from all county-owned and operated facilities, made up 44% of Clark County's 2022 operational emissions, contributing approximately 5,323 $MTCO_2e$. This sector includes emissions from the use of electricity, natural gas, propane, and fuel oil to heat, cool, and power county government facilities, as well as diesel generators used for backup power. The breakdown of government operations emissions by fuel type is shown in Figure 12.

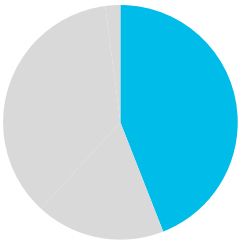
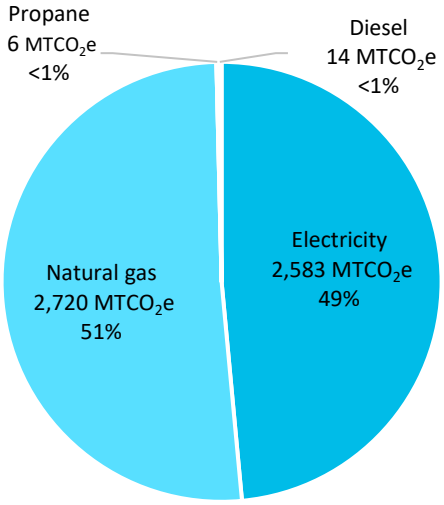
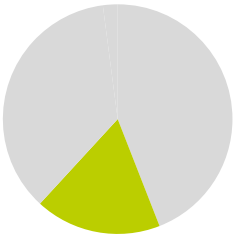


FIGURE 12. GOVERNMENT OPERATIONS BUILT ENVIRONMENT EMISSIONS, BY FUEL TYPE.

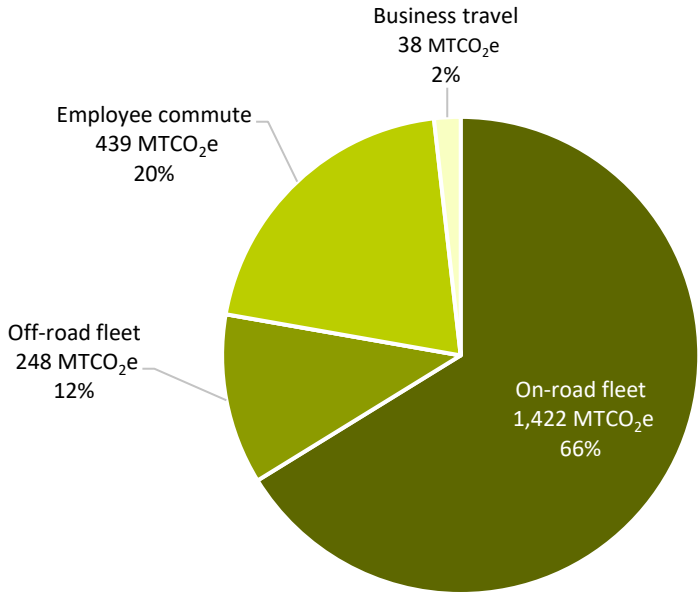


Transportation



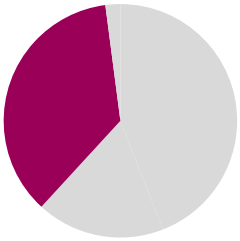
County operations transportation emissions stem from the operation of county fleet vehicles and equipment, county employee commuting, and county staff business travel (as data are available). Emissions from this sector made up 18% of Clark county's 2022 operational emissions (approximately 2,148 $MTCO_2e$). A breakdown of Clark County operations transportation emissions are shown below in Figure 13.

FIGURE 13. GOVERNMENT OPERATIONS TRANSPORTATION EMISSIONS, BY SOURCE.



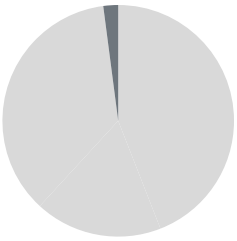
Solid Waste & Wastewater

The solid waste and wastewater sector made up 36% of Clark County's 2022 operational emissions, contributing approximately 4,362 $MTCO_2e$. This sector includes emissions from the county government's generation and disposal of solid waste, emissions from county-owned landfills (as applicable), energy used to convey water to county facilities, and process emissions from any county-owned wastewater facilities. Note that some of these sources may have been excluded due to data availability limitations.



Refrigerants

The refrigerant sector made up an estimated 2% of Clark County's 2022 operational emissions (249 $MTCO_2e$). This sector includes emissions from the use, leakage, and disposal of stationary refrigerants in county facilities, as well as mobile refrigerant use in county fleet vehicles and equipment.



Future Emissions Forecast & Scenario Analysis

Results from the 2022 communitywide GHG inventory were used to forecast future emissions and emission reduction scenarios for Clark County. Specifically, the analysis[7] forecasted Clark County's communitywide GHG emissions to 2050 under three scenarios, detailed in the sections below:

- Business-as-usual (BAU), which assumes no action is taken and assumes the projected population[8] and economic growth. [9] [10]
- Adjusted business-as-usual (ABAU), which models estimated emissions reduction from existing federal, state, and regional policies.
- Additional local action, which models estimated emissions reduction from local strategies such as VMT reduction and building energy efficiency.

In addition to these scenarios which consider all of Clark County's emissions, a "core emissions" forecast is shown below, which represents projected emissions only for the "core" emission sources included in the communitywide inventory. Core emissions that were included in this inventory include emissions from electricity, natural gas, on-road vehicles, solid waste generation and disposal, and wastewater treatment processes. These emissions are produced by sectors that are commonly included in community greenhouse gas inventories and which county governments often have the most influence.

Findings Summary

A summary of key findings from the 2022-2050 forecast and scenario analysis is provided in Table 4 below for both the core and all emissions sources.

TABLE 4. EMISSIONS FORECAST FOR 2050, UNDER THREE SCENARIOS (% CHANGE COMPARED TO 1990 BASELINE).

Scenario	Core Emissions	All Emissions
Business-as-Usual	+40%	+33%
Adjusted Business-as-Usual	-56%	-41%
Local Action	-92%	-88%

Emission levels for 1990 were estimated based on state-level emissions trends between 1990 and 2022.

[7] The forecast scenarios shown in this report are shown as examples of potential emission reduction pathways and may not reflect the scenarios represented in Clark County's Climate Element or associated analyses.
[8] Washington Office of Financial Management (OFM) Growth Management Act population projections, "Middle" scenario.
[9] Future employment estimated using expected OFM population growth percentages.
[10] Please note that the growth forecasts used in this analysis were selected in order to achieve consistency between Washington counties, and may not reflect the growth forecast used in Clark County's Comprehensive Plan update.

FIGURE 14. FORECASTED GHG EMISSIONS AND REDUCTIONS UNDER THREE SCENARIOS - CORE EMISSIONS.

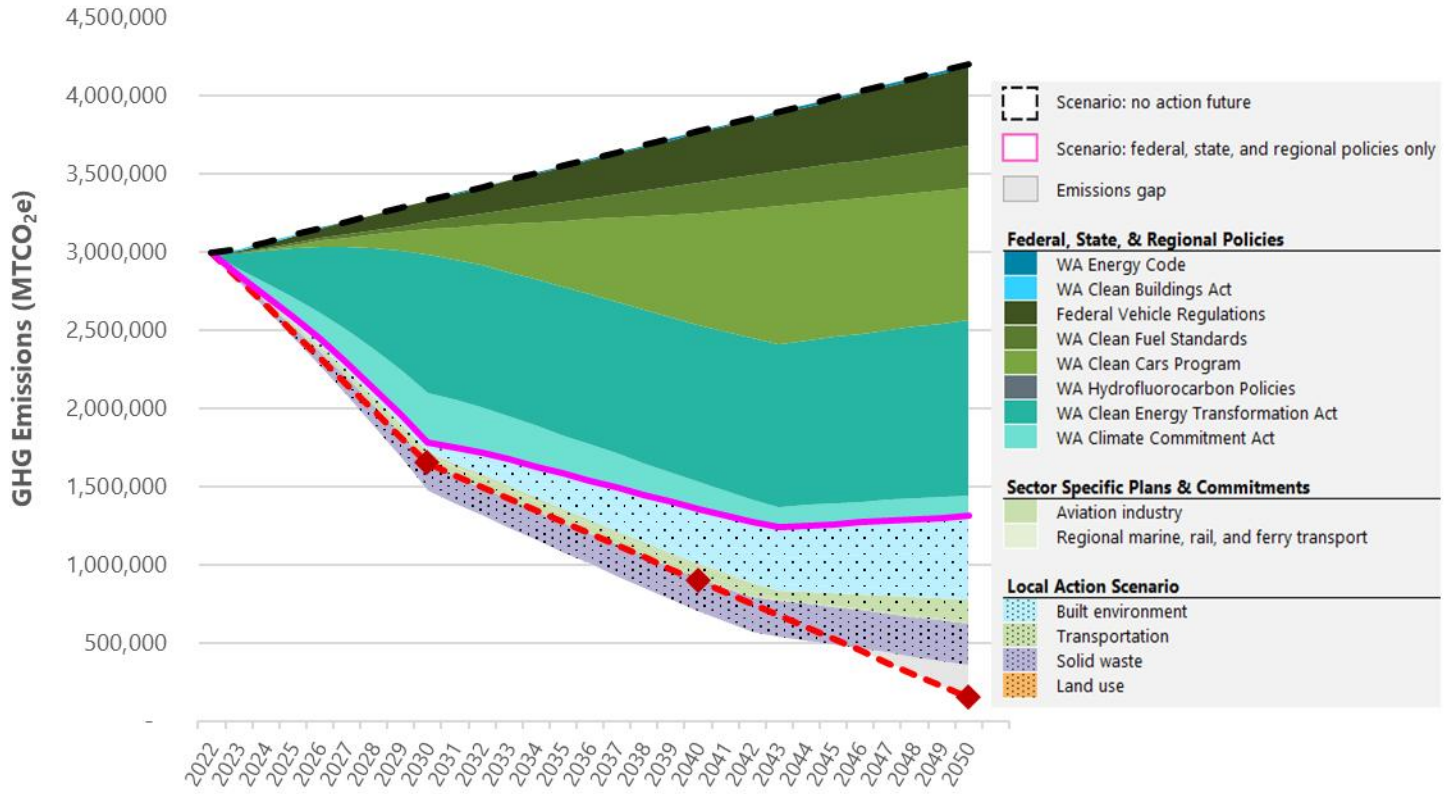
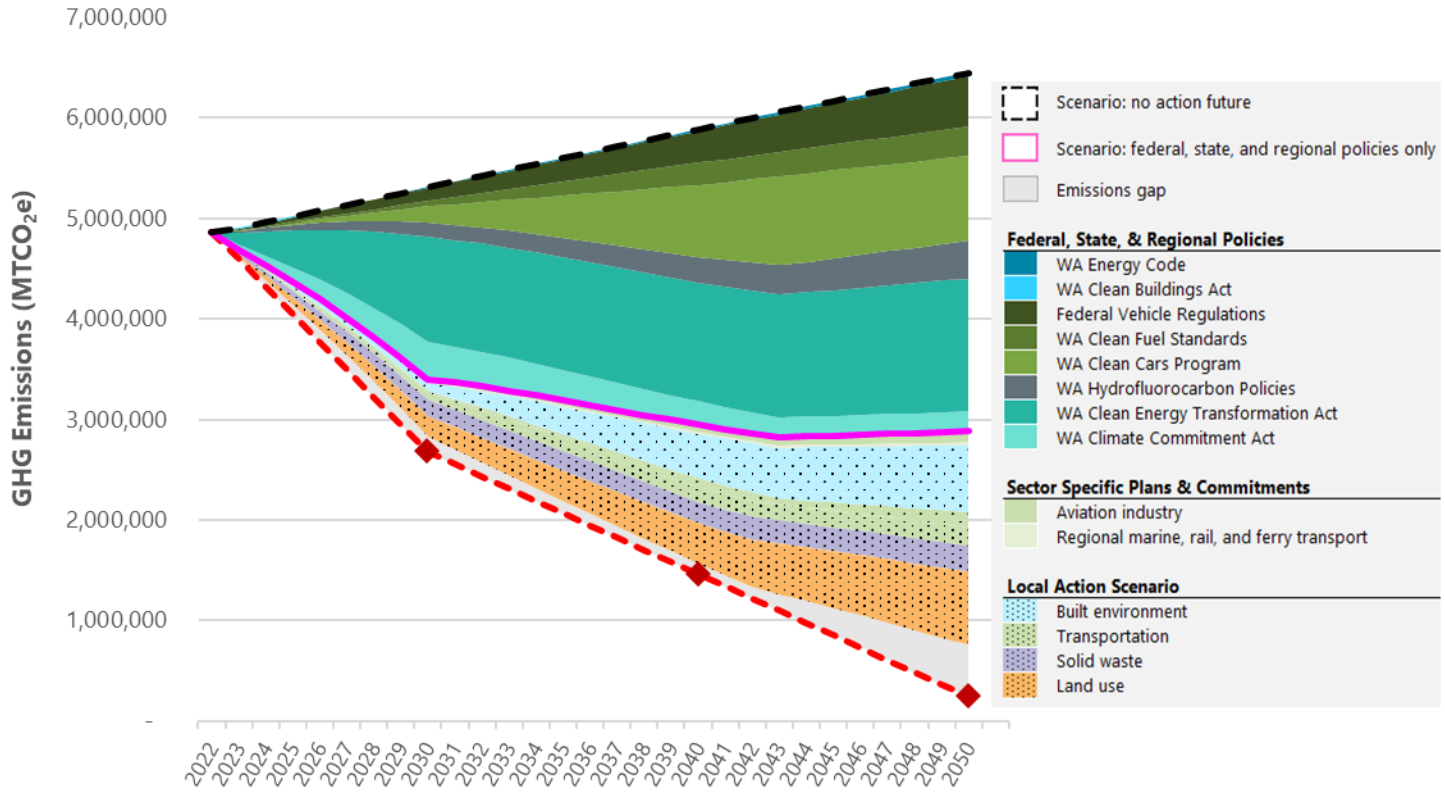


FIGURE 15. FORECASTED GHG EMISSIONS AND REDUCTIONS UNDER THREE SCENARIOS - ALL EMISSIONS.



The following sections provide a detailed summary of each scenario, including underlying assumptions and policy-specific findings.

Business-as-Usual Scenario

The BAU projects emissions based on a "no-action future" that assumes no federal, state, regional, or local policies or actions influence future emissions. Future emissions under the BAU are based on estimated population and economic growth. Population and economic growth estimates can be found in Table 5.

- Total Emission Forecast: The BAU projects a 33% growth in total emissions by 2050.
- Core Emission Forecast: The BAU projects a 40% growth in core emissions by 2050.

TABLE 5. DEMOGRAPHIC PROJECTIONS FOR CLARK COUNTY.

Demographic	2022	2030	2040	2050
Population	520,900	583,307	660,653	735,724
Employment	175,829	196,894	223,002	248,343

Adjusted-Business-as-Usual Scenario

The ABAU estimates emissions reductions resulting from established federal, state, and regional policies. Together, the implementation of identified policies results in an estimated 41% reduction in communitywide GHG emissions by 2050 compared to 1990 levels.

The ABAU scenario considered the following federal, state, and regional policies. Appendix B provides additional information regarding policy interpretation and assumptions.

- Washington State Energy Code (SB 5854)
- Washington Clean Buildings Act (HB 1257)
- Federal Vehicle Regulations (CAFE)
- WA Clean Fuel Standard (HB 1091)
- WA Clean Cars Program (SB 5974)
- WA Hydrofluorocarbon Policies (HB 1112 & HB 1050)
- WA Clean Energy Transformation Act (CETA)
- WA Climate Commitment Act (E2SSB 5126)

Note that to avoid double-counting, the analysis sequentially models each policy, so the order of modeling influences a policy's indicated GHG emission reductions.

Local Action Scenario

The local action scenario models additional emissions reductions from county-level local strategies, such as land use policies to encourage transportation mode shift and building energy efficiency. The intention of this scenario is to support identification and prioritization of local policies for inclusion in a GHG emission reduction sub-element. The local action scenario, which represents just one of many potential paths to achieving GHG emission reductions, provides a pathway toward achieving the state's GHG emission reduction target (95% reduction in GHG emissions by 2050 compared to a 1990 baseline). Note that several of these strategies may address emission sources that are expected to be reduced through existing federal, state, and regional legislation, which may make local strategies appear less impactful. Table 6 and Table 7 below summarize the local action scenario and associated reductions.

TABLE 6. LOCAL ACTION SCENARIO AND GHG EMISSION REDUCTIONS ($MTCO_2E$) - CORE EMISSIONS.

Local Strategy	2050 Value	Cumulative emissions reduction to 2050 ($MTCO_2e$)	Proportion of local strategy reductions (%)
Electrify new buildings (% fossil fuel use converted to elect.)	100%	833,421	6%
Reduce energy use in existing buildings (% reduction in energy use)	45%	3,447,071	24%
Electrify existing buildings (% fossil fuel use converted to elect.)	95%	2,917,871	20%
Reduce passenger vehicle travel (% reduction in per-capita VMT)	20%	354,427	2%
Electrify passenger vehicles (% new vehicles sold that are EV)	100%	735,003	5%
Electrify freight/service vehicles (% new vehicles sold that are EV)	80%	1,054,380	7%
Electrify transit vehicles (% new vehicles sold that are EV)	90%	110,957	<1%
Divert C&D materials (% of C&D waste diverted)	85%	5,094,780	35%
Divert other recyclable and compostable materials (% reduction in waste to landfill)	95%		
Total Emission Reductions		**14,547,911**	**100%**

TABLE 7. LOCAL ACTION SCENARIO AND GHG EMISSION REDUCTIONS ($MTCO_2E$) - ALL EMISSIONS.

Local Strategy	2050 Value	Cumulative emissions reduction to 2050 ($MTCO_2e$)	Proportion of local strategy reductions (%)
Electrify new buildings (% fossil fuel use converted to elect.)	100%	923,592	3%
Reduce energy use in existing buildings (% reduction in energy use)	45%	3,973,193	14%
Electrify existing buildings (% fossil fuel use converted to elect.)	95%	3,362,040	12%
Reduce industrial emissions (% reduction in emissions)	50%	671,983	2%
Reduce passenger vehicle travel (% reduction in VMT)	20%	354,424	1%
Electrify passenger vehicles (% new vehicles sold that are EV)	100%	735,078	3%
Electrify freight/service vehicles (% new vehicles sold that are EV)	80%	1,054,381	4%
Electrify transit vehicles (% new vehicles sold that are EV)	90%	110,957	<1%
Decarbonize offroad equipment (% reduction in emissions)	95%	2,479,943	9%
Divert C&D materials (% of C&D waste diverted)	85%	5,094,780	18%
Divert other recyclable and compostable materials (% reduction in waste to landfill)	95%		
Improve soil management (% reduction in emissions)	75%	201,642	<1%
Reduce tree loss (% reduction in tree loss)	90%	9,705,368	34%
Total Emission Reductions		**28,667,382**	**100%**

Remaining Emissions

In 2050, the largest sources of remaining emissions under the local action scenario are on-road vehicles (26%), aviation (18%), and tree loss (13%). Under the "Core" forecast's local action scenario, the largest sources of remaining emissions in 2050 are on-road vehicles (67%), natural gas (13%), and solid waste generation & disposal (11%). The makeup of remaining emissions is depicted in Figure 16 and Figure 17 below.

FIGURE 16. FORECASTED GHG EMISSIONS AND REDUCTIONS UNDER THREE SCENARIOS ($MTCO_2E$) - CORE EMISSIONS.

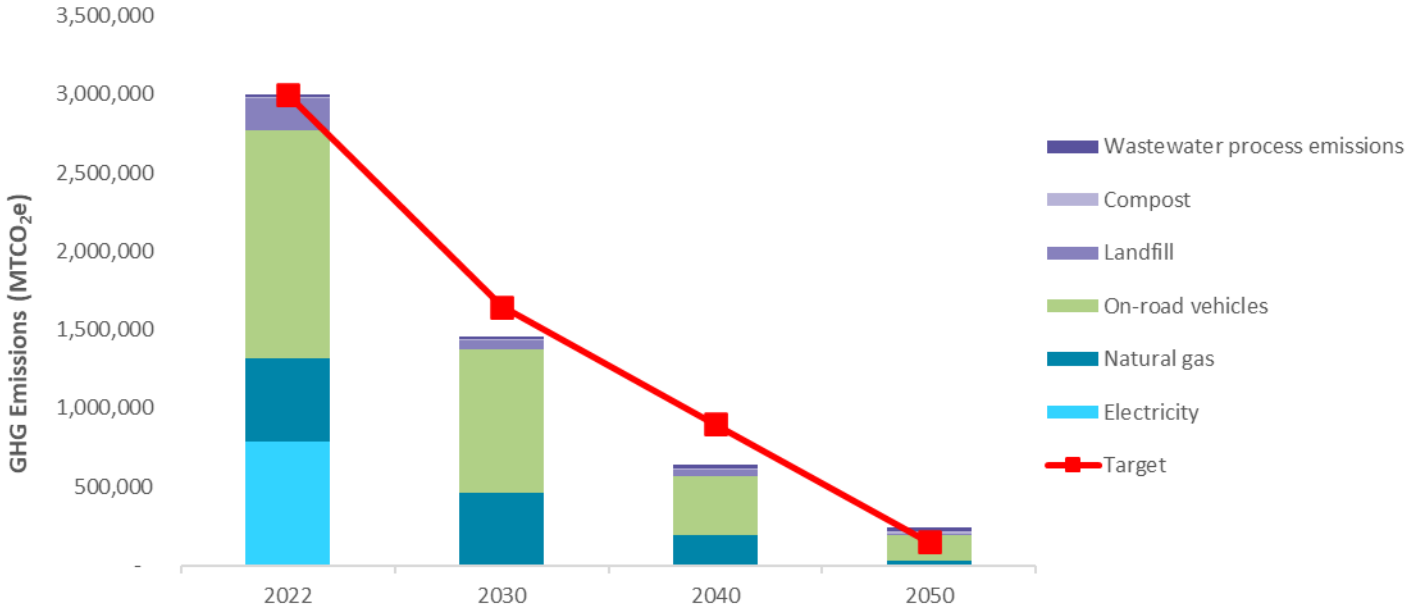
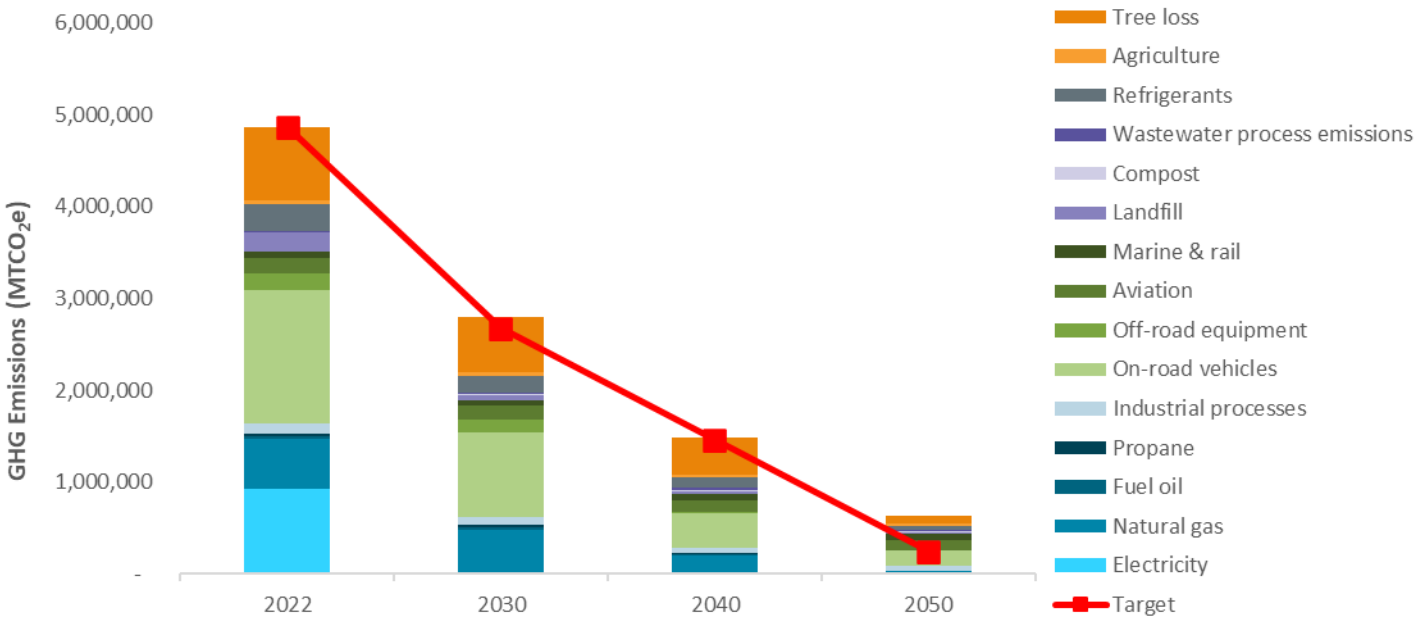


FIGURE 17. FORECASTED GHG EMISSIONS AND REDUCTIONS UNDER THREE SCENARIOS ($MTCO_2E$) - ALL EMISSIONS.



Local Policy Options

These analyses of current and projected future GHG emissions provide insight into local policy options for reducing GHG emissions in Clark County. As presented in the local action scenario, key GHG emission reduction strategies for focus in Clark County's comprehensive plan update include:

- Reduce energy consumption in new and existing residential and commercial buildings through: 1) supporting clean building energy sources and 2) energy efficient building design and retrofits. Local action to transition to renewable building energy sources would reduce Clark County's built environment emissions, which made up 34% of 2022 communitywide emissions.
- Reduce passenger vehicle travel within the county, including through changes to land use, transportation infrastructure (transit, walking, bicycling), and commuting options/modes. A reduction in passenger VMT would reduce Clark County's communitywide on-road emissions from passenger vehicles, which made up 21% of 2022 emissions.
- Facilitate the transition to electric vehicles through expansion of reliable EV charging infrastructure and public education on options and available incentives/rebates. Local action to support transitioning passenger and freight vehicles to electric would reduce Clark County's passenger and freight vehicle on-road emissions, which made up 30% of 2022 communitywide emissions.
- Limit tree loss and support low-carbon land practices such as sustainable forestry, agriculture, and livestock management. Reducing tree loss emissions and emissions from agricultural practices in Clark County would reduce land use emissions, which made up 17% of 2022 communitywide emissions.
- Work with local industries to support transition to low-carbon industrial processes, including for high-carbon industries such as semiconductor device manufacturing and operating paper mills. These industrial process emissions made up 2% of Clark County's 2022 communitywide emissions.

Appendix A: GHG Inventory Methodology

Emissions Sectors

Communitywide

The communitywide GHG emissions inventory included the sectors depicted in Table 8 below. Some of the sectors are classified as "core" emissions sources; Table 8 identifies these core emissions sources and the rationale for their classification. Core emissions sources also align with the five basic emissions generating activities that are required for community inventories per the U.S. Community Protocol for Accounting and Reporting of GHG Emissions[11]. While agriculture, tree loss, and some other emissions sources are not included in the core emissions scenario, Commerce still strongly encourages local jurisdictions to consider comprehensive plan policies to address emissions from these sources. Such policies will support co-benefits such as clean air and water, improve resilience, and provide beneficial opportunities such as local food systems.

TABLE 8. COMMUNITYWIDE GHG EMISSIONS INVENTORY SECTORS.

Sector	Core?	Required?	Rationale
Built Environment			
Electricity	**Yes**	✓	Local governments can often influence electricity use in local buildings through local building codes, financial incentives, minimum regulatory requirements, technical assistance, and other programs.
Natural gas	**Yes**	✓	Local governments can often influence use of fuels in stationary combustion applications (e.g., furnaces) in local buildings through local building codes, financial incentives, minimum regulatory requirements, technical assistance, and other programs. *Note: Be advised that I-2066, approved by Washington voters in November 2024, prevents counties, cities, and towns from adopting policies that prohibit, penalize, or discourage natural gas heating in buildings and appliances and equipment within buildings. Check with your jurisdiction's legal counsel about impacts to your jurisdiction.*
Fuel oil & propane	No		Often a smaller emissions source; less confident in local specificity of the data (estimated using downscaled state-level data).
Industrial processes	No		Local governments have less direct control over large industrial sources; they are regulated at the state and federal level.
Transportation			
On-road vehicles	**Yes**	✓	Local governments can influence transportation emissions through land use and urban design regulations and through transportation infrastructure investments.
Off-road equipment	No		Often a smaller emissions source; local governments have less influence over off-road equipment fuel usage.
Aviation	No		Local governments have less influence over aviation fuel mix and passenger air travel behavior.
Marine & rail	No		Often a smaller emissions source; local governments have less influence over marine/rail activity and fuels.
Solid Waste & Wastewater			
Solid waste generation & disposal	**Yes**	✓	Local governments can influence the amount of solid waste generated and sent to various disposal methods through their administration of municipal solid waste, recycling and composting services.

[11] U.S. Community Protocol | ICLEI USA

Sector	Core?	Required?	Rationale
Compost generation & disposal	Yes		Local governments can influence the amount of solid waste generated and sent to various disposal methods through their administration of municipal solid waste, recycling and composting services. Compost emissions are often much lower than landfilled waste emissions.
Wastewater treatment processes and septic systems	Yes		Local governments can influence community water use through local building codes, promoting and/or providing incentives to foster conservation and efficiency, and other programs and services.
Refrigerants			
Refrigerants	No		Often a smaller emissions source; less confident in local specificity of the data (estimated using downscaled national-level data).
Land Use			
Agriculture	No		Local governments have less influence over agricultural management practices; less confident in local specificity of the data (management practices are assumed based on national trends).
Tree loss and tree carbon sequestration	No		Local governments have less influence over management of forests and other natural resources owned by private entities and state and federal agencies; data represent an average over a 3+ year time period so may not reflect current trends.

County Operations

The county government operations GHG emissions inventory sought to include the sectors depicted in Table 9 below. These sectors represent Scope 1, 2, and 3 emissions sources, which are defined as follows:

- Scope 1: All direct GHG emissions sources
- Scope 2: Indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling.
- Scope 3: All other indirect emissions not covered in Scope 2.

Depending on data availability, not all sectors may have been included in Clark County's county operations GHG inventory. The Local Government Operations Protocol notes that local governments should, at a minimum, quantify and report all Scope 1 and 2 emissions, and reporting of Scope 3 emissions is optional.

TABLE 9. COUNTY OPERATIONS GHG EMISSIONS INVENTORY SECTORS.

Sector	Scope	Description
Built Environment		
Electricity	2	Amount of electricity (in kWh) consumed by County-owned buildings and facilities, including any County-owned utilities and streetlights/traffic signals, as well as the amount of electricity (in kWh) consumed by any green program enrollment.
Natural gas	2	Amount of natural gas (in therms) consumed by County-owned buildings and facilities.
Other fuels	1	Amount of propane and fuel oil (in gallons) consumed by County-owned buildings and facilities, including any City-owned utilities.
Power generation	1	Fuel type and amount consumed by County generators.
Transportation		
County vehicles & equipment	1	Vehicle fleet inventory includes on-road and off-road fleet and equipment.
Employee commute	3	Employees commuting passenger miles travelled by transit type (e.g. car, bus, ferry).
Business travel	3	Business travel miles by mode (e.g. passenger vehicle, train, or air travel).
Solid Waste & Wastewater		
Solid waste & compost	1	Total solid waste generated by County operations during inventory year (in tons) by waste stream (e.g. landfill, recycling, compost). If tonnage is unavailable, please provide the number of bins per waste type, estimated fullness per bin, and pickup frequency.

Sector	Scope	Description
County landfills	1	Landfill characteristics owned/operated by the County (ex. Waste in place, open year, close year, etc.).
Wastewater treatment processes	2	Wastewater generation data from wastewater treatment plants.
Water conveyance	2	Amount of electricity (in kWh) consumed for water conveyance.
Refrigerants		
Stationary refrigerants	1	The total amount of refrigerants (in lbs.) used to fill or refill refrigeration equipment.
Mobile refrigerants	1	The total amount of refrigerants (in lbs.) used to fill or refill fleet air conditioning.

Methodology and Data Sources

Calculating Clark County's GHG emissions inventories involved identifying and applying emissions factors to activity data:

- Activity data quantify levels of activity that generate GHG emissions, such as vehicle miles traveled and kWh of electricity consumed.
- Emission factors (EFs) translate activity levels into emissions (e.g., $MTCO_2e$ per kWh).

The tables and sector sections below provide an overview of methodologies for each emissions sector in the communitywide and County government operations inventories. Any deviations or data limitations specific to Clark County are noted in the "Approach and Data Limitations" section on page A-12.

TABLE 10. COMMUNITY GHG INVENTORY: KEY APPROACHES AND DATA SOURCES.

Sector	Activity Data	Emissions Factors (EFs)
Built Environment		
Electricity	County-wide consumption provided by utilities	1) Utility-specific emission factors (from Department of Ecology Clean Fuel Standard program utility-specific electricity calculations) 2) Emissions & Generation Resource Integrated Database (eGRID) EFs (for informational purposes only)
Natural gas	County-wide consumption provided by utilities	1) Utility-specific emission factors, where available 2) U.S. EPA EF Hub average EFs (where utility-specific EFs were not available)
Fuel oil	WA fuel oil consumption by sector from U.S. Energy Information Administration (EIA)	U.S. EPA EF Hub average EFs
Propane	WA propane consumption by sector from U.S. EIA	U.S. EPA EF Hub average EFs
Industrial processes	EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT)	N/A - data reported in emissions
Transportation		
On-road vehicles	Two approaches[12]: 1) Vehicle miles traveled data from Washington State Department of Transportation (WSDOT) Highway Performance Monitoring System (HPMS) 2) Vehicle miles traveled estimates from StreetLight for home-based resident vehicle trips and work-based employee vehicle trips	U.S. Environmental Protection Agency (EPA) Emission Factors Hub[13] vehicle EFs (by vehicle & fuel type)

[12] See more information regarding these two approaches in the "Transportation" section below.
[13] EPA Emission Factors Hub

Sector	Activity Data	Emissions Factors (EFs)
Off-road equipment	EPA Motor Vehicle Emission Simulator (MOVES) model outputs, by county	N/A (data reported in emissions)
Public transit	Reported transit vehicle miles traveled by fuel type for each transit agency from the National Transit Database (NTD)	U.S. EPA Emission Factors Hub vehicle EFs (by vehicle & fuel type)
Aviation	Two approaches, depending on data availability: 1) Volume of fuel (jet-A and aviation gasoline) loaded onto all planes departing from airports within county; volume of all fuel used in helicopters, light aircraft operating within county boundaries (e.g., police, sightseeing, training) 2) Number of landing and takeoff cycles that could be used to estimate fuel based on similar airports Emissions from Seattle-Tacoma International Airport (SEA) and Portland International Airport (PDX) were attributed to individual counties using Approach 1 (described above), in combination with passenger survey data, population, and household income data from the U.S. Census.	U.S. EPA EF Hub average emission factors, by fuel type
Marine	US EPA National Emissions Inventory (NEI) estimates by county (for commercial marine vessels)	N/A (data reported in emissions)
Rail	U.S. EPA National Emissions Inventory (NEI) by county (for freight and passenger rail use)	N/A (data reported in emissions)
Solid Waste & Wastewater		
Solid waste generation & disposal	County-wide tonnage and local waste characterization data, as available. Where local waste characterization data were unavailable, Department of Ecology regional characterizations were used.	EPA Waste Reduction Model (WARM) EFs, customized for landfill attributes
Compost generation & disposal	County-wide tonnage and WA state organics characterization study	EPA WARM EFs
Wastewater treatment processes	Wastewater treatment data by wastewater treatment facilities (including gallons processed)	U.S. Community Protocol default EFs, customized for wastewater treatment facility process specifications (unless a treatment facility provided customized emission calculations)
Septic systems	Number of reported septic systems	U.S. Community Protocol default EFs
Refrigerants		
Refrigerants	EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022	N/A - reported in terms of emissions
Land Use		
Agriculture	County-specific acres of cropland and number of livestock (from U.S. Department of Agriculture Census of Agriculture)	U.S. Community Protocol defaults by animal / management scenario
Tree cover	ICLEI Land Emissions and Removals Calculator - reported in terms of emissions	

TABLE 11. COUNTY GOVERNMENT OPERATIONS GHG INVENTORY: KEY APPROACHES AND DATA SOURCES.

Sector	Activity Data	Emissions Factors (EFs)
Built Environment		
Electricity	Consumption by County facilities	Utility-specific emission factors (from Department of Ecology Clean Fuel Standard program utility-specific electricity calculations)
Natural gas	Consumption by County facilities	Utility-specific emission factors
Other fuels	Consumption by County facilities	U.S. EPA EF Hub average EFs
Power generation	Consumption by County facilities	U.S. EPA EF Hub average EFs
Transportation		
County fleet vehicles & equipment	Fuel consumption data for County vehicles and equipment	US Environmental Protection Agency (EPA) Emission Factor Hub vehicle EFs (by vehicle & fuel type)
Employee commute	Total employees commuting passenger miles travelled	N/A
Business travel	Total employee business travel miles travelled	N/A
Solid Waste & Wastewater		
Solid waste & compost	Estimated tonnage based on waste hauler invoices (container size and pickup frequency) Assumed waste characterization consistent with community commercial sector	EPA Waste Reduction Model (WARM) EFs, customized for landfill attributes
County landfills	Tons of waste in place	Reported emissions from EPA FLIGHT dataset
Wastewater treatment	Wastewater treatment data by wastewater treatment facilities (including gallons processed)	U.S. Community Protocol default EFs, customized for wastewater treatment facility process specifications (unless a treatment facility provided customized emission calculations)
Water conveyance	Energy consumption by County facilities	Utility-specific emission factors
Refrigerants		
Stationary refrigerants	County-reported refrigerant use	IPCC Sixth Assessment Report (AR6) Global Warming Potentials (GWP)
Mobile refrigerants	County-reported refrigerant use	IPCC Sixth Assessment Report (AR6) Global Warming Potentials (GWP)

Communitywide

Building Energy

Electricity

Emissions from electricity consumption were determined using the amount of electricity consumed in 2022 within each county, multiplied by utility- and year-specific emission factors. Residential, commercial, and industrial electricity consumption data were procured directly from the utilities that provide service to each county. Emissions from electricity transmission and distribution (T&D) were included in the utility-specific emission factors used for these inventories, provided by the WA Department of Ecology.

Natural Gas

Emissions from natural gas consumption were determined by multiplying the natural gas consumed in 2022 within each county by utility- and year-specific emission factors (as available). Residential, commercial, and industrial natural gas consumption data were procured directly from the utilities that provide service to each county. Emissions from natural gas leakage were calculated using utility-specific leakage rates if available, or

using a default leakage rate from the Environmental Defense Fund's "User Guide for Natural Gas Leakage Rate Modeling Tool"[14]. Other default values necessary to calculate fugitive emissions from natural gas were provided by ClearPath, ICLEI's greenhouse gas inventory software platform.

Propane & Fuel Oil

Residential propane and fuel oil emissions were calculated using 2022 U.S. EIA residential and commercial propane and fuel oil consumption data for the state of Washington. Statewide total residential fuel sales were allocated to counties using U.S. Census American Community Survey (ACS) home heating fuel data. Commercial propane and fuel oil emissions were calculated using WA commercial fuel consumption estimates downscaled by the number of commercial employees within each county as compared to total state employment. Employment data were collected from the WA Employment Security Department, which provides data on the number of employees across industries. Propane and fuel oil emissions were both calculated using U.S. EPA emissions factors. Industrial propane and fuel oil were not calculated due to potential overlap with the industrial process emissions sector (see below).

This December 2025 report update incorporates newly available 2022 EIA residential and commercial consumption data (the July 2025 version used 2021 data as a proxy, as 2022 data were not yet published).

Industrial Processes

Emissions from industrial processes in 2022 were obtained from EPA's Facility Level Information on Greenhouse Gases Tool (FLIGHT). Data was available for download by county for large facilities (>25,000 $MTCO_2e$) required to report annual data about GHG emissions to EPA as part of the Greenhouse Gas Reporting Program. To avoid double counting with other inventory sectors such as solid waste and buildings, EPA FLIGHT data from landfill facilities and facility energy consumption (e.g., natural gas) were excluded.

Transportation

On-Road

On-road GHG emissions were estimated using 2022 VMT activity data from WSDOT's Highway Performance Monitoring System (HPMS), which provides estimated annual VMT for all public roadways in each county. VMT for each county was split into light, medium, and heavy-duty VMT based on WSDOT HPMS statewide freight percentages. For medium- and heavy-duty freight emissions, VMT was multiplied by fuel- and vehicle-specific emissions factors from the 2022 EPA Emission Factors Hub. For light-duty vehicles, 2022 vehicle registration data from each county was used to estimate VMT by fuel type, which was then multiplied by fuel-specific emissions factors from the EPA Emission Factors Hub. The vehicle registration data was also used to create a weighted emissions factor for light-duty gasoline vehicles, based on the split between passenger vehicles and light trucks in each county.

Using HPMS data is an alternative for obtaining VMT activity data for jurisdictions that do not have a travel demand model calibrated to current conditions. HPMS estimates VMT using traffic counts on public roadways. These counts are expanded using statistical sampling and road segment characteristics (e.g., functional class, urban/rural designation) to estimate total VMT across all public roads within each county. While HPMS data offers a consistent, annually reported dataset and is useful for producing jurisdiction-level VMT estimates, it has less explanatory power compared to travel demand models, which incorporate land use, network connectivity, and regional behavior patterns.

[14] U.S. Natural Gas Leakage Model User Guide | EDF

Both travel demand model and HPMS data focus on VMT occurring within and passing through the area, rather than the VMT generated by the area itself (even if that VMT passes outside of the area boundary). While travel demand models can estimate VMT generated by an area, it is a more complex calculation than the geographic boundary-based approach. Understanding VMT generated by the area offers valuable context for developing targeted reduction strategies, as it reflects the driving activity of residents and workers within the jurisdiction while excluding pass-through traffic on interstates and major roadways. Many local VMT reduction strategies, such as providing transit passes, aim to influence the travel behavior of residents and workers, making person-level VMT data particularly useful for policy development. While geographic-boundary based approaches for VMT provide a consistent and reliable estimate of VMT and associated GHG emissions, person-level VMT data can complement this by offering deeper insights to support effective VMT reduction goals.

To supplement the VMT data, estimates for home-based VMT per resident and home-based work VMT per employee were provided by StreetLight Data for each county. The methodology involves several steps using Location-Based Services (LBS) data to create a detailed and accurate metric. First, StreetLight data analyzes all vehicle trips that either start or end within the selected geography. These trips are then assigned to residents or employees based on inferred home and work locations. The trips are further classified by purpose, such as home-to-work or home-to-other trips. Average trip lengths are then calculated for each category. The VMT estimates are obtained by multiplying the average trip length by the vehicle volumes for each trip category, and these estimates are normalized for residents and employees. More information regarding this methodology can be found in Appendix E.

Off-Road

Off-road emissions were acquired from EPA's Motor Vehicle Emissions Simulator (MOVES) model version 4.0. Using county-level defaults, the MOVES nonroad module was used to output 2022 daily emissions for all available off-road sectors, including agriculture, airport support, commercial, construction, industrial, lawn and garden, logging, oil field, pleasure craft, railroad, recreational, and underground mining. The equipment included in these sectors included self-propelled vehicles, such as construction equipment, as well as handheld equipment like chainsaws. MOVES output was provided for by weekday and weekend day for each month. The results were multiplied by the appropriate number of weekdays and weekend days in 2022 to determine annual emissions. The model produces CH_4 and CO_2 emissions per sector for gasoline, LPG, CNG, and diesel.

Public Transit

Transit emissions were based on annual fuel use and vehicle-miles-traveled data for each transit agency, obtained from the National Transit Database report for 2022. Annual fuel use was multiplied by standard fuel- and vehicle-specific emissions factors from the EPA Emission Factors Hub.

Aviation

Aviation emissions were based on the fuel used by aircraft at each airport. Gallons of jet fuel and aviation gasoline were multiplied by standard fuel-specific emission factors from the EPA Emission Factors Hub. Emissions from regional and municipal airports were assigned to the county in which the airport is located.

Portland International Airport (PDX) is not located in Clark County; however, many residents of Clark County utilize PDX for air travel. PDX provided passenger survey data that identified the percentage of departing passengers whose home is Clark County. These data were used to attribute a portion of the airport's 2022 fuel consumption data to Clark County.

Marine

Emissions from marine sources were estimated for commercial marine vessels. Pleasure craft were reported as off-road vehicles/equipment. Emissions from commercial marine vessels were obtained from EPA's National Emissions Inventory (NEI) 2020 NEI Data Retrieval Tool, by county. In the absence of 2022 data or scaling factors related to commercial activity, it was assumed that 2022 emissions were equivalent to 2020 emissions.

NEI commercial marine data includes emissions from the Washington State Ferry (WSF) system. WSF has begun implementation of its System Electrification Plan, which is projected to decrease fleetwide GHG emissions by 75% by 2040. To understand the contribution of ferry vessel emissions to the total commercial marine vessel sector, emissions from WSF vessels were determined by scaling the emissions reported in the 2016 Puget Sound Maritime Emissions Inventory by fuel use in 2016 and 2022 (these calculations were performed for informational purposes only).

Rail

Emissions from freight and passenger rail were obtained from EPA's National Emissions Inventory 2020 NEI Data Retrieval Tool, by county. In the absence of 2022 data or scaling factors related to commercial activity, it was assumed that 2022 emissions were equivalent to 2020 emissions.

Solid Waste and Wastewater

Solid Waste Generation and Disposal

Emissions from the generation and disposal of landfilled solid waste were estimated by multiplying the tons of waste generated in 2022 by material-specific emissions factors derived from the U.S. EPA WARM v16 model. If locally specific solid waste tonnage data were not attainable, WA Department of Ecology "Solid Waste Disposal Annual Summary, Recoverable and Non-Recoverable Wastes generated in Washington State, 1994-2021" tonnage data were scaled by population to estimate county-level waste generation. Waste and compost generation data were obtained from local waste haulers that serve each county, as available. Waste composition data, when available, were obtained directly from county staff. If recent waste characterization studies were unavailable, regional data from the WA Statewide 2020 Waste Characterization Study were used. These characterization data were translated into U.S. EPA WARM categories to estimate emissions by material type, and EFs were applied to estimate methane emissions based on the landfill's unique characteristics and methane capture scenario. Emissions from transportation of waste to landfills were estimated using estimated travel distance (from Google Maps) and default EFs from the U.S. Community Protocol.

Wastewater Treatment Processes

Emissions from the treatment of wastewater produced by each county were estimated based on reported 2022 data from wastewater treatment plants. Emissions were estimated based on the type of treatment processes at a given plant—such as the use of anaerobic digestion or the use of nitrification/denitrification—as well as the population served. Based on the data reported by each facility, emissions were calculated using U.S. Community Protocol default equations. Where facilities were unable to directly provide the necessary data to estimate process emissions, the treatment plant service area was used to estimate population served and emissions were estimated using data from U.S. EPA compliance reports for that wastewater treatment facility.

Septic Systems

To determine emissions from septic systems, the estimated population served by septic systems was estimated using the 1) number of septic systems within each county and 2) average population per household in that county as of 2022 (as reported by the U.S. Census). Emissions were then estimated using default equations from the U.S. Community Protocol.

Refrigerants

Emissions from refrigerant use were obtained from U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2022. Total refrigerant emissions were downscaled to each county based on the U.S.-to-county population ratio, using Washington Office of Financial Management (OFM) county population estimates. For this updated December 2025 version of the inventory report, the population data source was revised from U.S. Census county populations to OFM estimates to improve consistency with other sections of the inventory.

Land Use

Agriculture

Agricultural emissions were calculated following the U.S. Community Protocol methodology. Agricultural emissions stem from livestock enteric fermentation, manure management, and soil. For these calculations, the U.S. EPA Inventory Annexes provided values for the following: livestock enteric fermentation emissions factors, distribution of waste management systems, typical animal mass, daily and annual volatile solid production rates, maximum CH_4 producing capacity per pound of manure, methane conversion factors based on manure management system, daily excreted nitrogen rates, nitrous oxide emissions factors, nitrogen lost through volatilization, and nitrogen lost through runoff and leaching. The U.S. Community Protocol Appendix G provided values for volatilization and runoff/leaching emissions factors. Data on the number of animals in each county was sourced from the USDA 2022 Census of Agriculture. The U.S. EPA Inventory and Inventory Annexes provided nationwide values for direct and indirect N_2O emissions from soils, and the total U.S. cropland acreage was provided by the 2022 USDA Census of Agriculture. This national data was used to create an emissions factor for soil, which was applied to the acres of cropland in each county.

Tree Loss & Carbon Sequestration

ICLEI's Land Emissions and Removals Navigator (LEARN) tool was used to estimate GHG emissions from tree cover loss and carbon sequestration from tree cover gain and maintenance within county boundaries. The LEARN tool uses the National Land Cover Database (NLCD), produced by the United States Geological Survey (USGS) as the land cover database for this analysis. The LEARN tool requires a minimum of a 3-year analysis timeframe, which was divided by three to determine an average annual value. At the time of this analysis, the tool was available through 2019; therefore, a 2016-2019 timeframe was analyzed. Default factors used to calculate emissions for the "Trees Outside Forests" category are based on data for Seattle, Washington (the tool allows for customization to major metropolitan areas; the only available Washington option is for Seattle). More information regarding this methodology can be found in Appendix D: Tree Canopy GHG Emissions & Sequestration Summary Report.

County Government Operations

Built Environment

Facility Electricity

Emissions from electricity consumption were determined by multiplying the amount of electricity consumed in 2022 within each county-owned and/or -managed facility by utility- and year-specific emission factors. Emissions from electricity transmission and distribution (T&D) were included in the utility-specific emission factors used for these inventories, provided by the WA Department of Ecology.

Facility Natural Gas

Emissions from natural gas consumption were determined by multiplying the natural gas consumed in 2022 within each county-owned and/or -managed facility by utility- and year-specific emission factors. Emissions from natural gas leakage were calculated using utility-specific leakage rates if available or using a default leakage rate from the Environmental Defense Fund's *User Guide for Natural Gas Leakage Rate Modeling Tool*.[15] Other default values necessary to calculate fugitive emissions from natural gas were provided by ClearPath, ICLEI's greenhouse gas inventory software platform.

Other Facility Energy Sources

Emissions from other facility fuel sources, including propane, fuel oil, and diesel, were calculated by multiplying the amount of fuel consumed within each county-owned and/or managed facility by default U.S. EPA emissions factors.

Transportation

On-Road Fleet Vehicles

GHG emissions from on-road county fleet vehicles were estimated by multiplying either fleet vehicle 1) fuel consumption or 2) miles traveled by fuel- and vehicle-specific emissions factors from the 2022 EPA Emission Factors Hub. Vehicle miles traveled data were translated to fuel consumption using average miles per gallon (mpg) estimates from the U.S. Department of Transportation Federal Highway Administration's (FHWA) "Annual Vehicle Distance Traveled in Miles and Related Data - 2022" dataset.

Off-Road Fleet Vehicles

GHG emissions from off-road county fleet vehicles were estimated by multiplying off-road fleet vehicle fuel consumption by fuel-specific emissions factors from the 2022 EPA Emission Factors Hub.

Transit Fleet

GHG emissions from county-owned and/or operated transit fleet vehicles were estimated using emissions estimates from the transit agency.

Employee Commute

GHG emissions from county employee commuting were estimated using available commuting data, such as from employee surveys or Washington State Commute Trip Reduction program reporting.

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[15] U.S. Natural Gas Leakage Model User Guide | EDF

Business Travel

GHG emissions from county employee business travel were estimated by multiplying standard emissions factors from the EPA Emissions Factors Hub by county-reported mileage data for ground and air travel.

Solid Waste and Wastewater

Solid Waste Generation and Disposal

Emissions from county government generation and disposal of landfilled solid waste were estimated by multiplying estimated total tons of waste generated in 2022 from county owned and/or managed facilities by material-specific emissions factors derived from the U.S. EPA WARM v16 model.

If local waste characterization studies were unavailable, regional data from the WA Statewide 2020 Waste Characterization Study were used. These characterization data were translated into U.S. EPA WARM categories to estimate emissions by material type, and emission factors were applied to estimate methane emissions based on the landfill's unique characteristics and methane capture scenario. Emissions from transportation of waste to landfills were estimated using estimated travel distance from county to landfill (Google Maps) and default emission factors from the U.S. Community Protocol.

Landfills

Emissions from county owned and/or operated landfills were estimated using EPA's Facility Level Information on Greenhouse Gases Tool (FLIGHT). Data was available for download by county for large facilities (>25,000 $MTCO_2e$) required to report annual data about GHG emissions to EPA as part of the Greenhouse Gas Reporting Program.

Wastewater Treatment Processes

Emissions county-owned and/or operated wastewater treatment facilities were estimated using reported emissions values from wastewater treatment facilities.

Water Conveyance

Emissions from county-owned and/or operated water conveyance systems (e.g., pump stations) were estimated using county- or utility-reported energy consumption (electricity, natural gas) and multiplying by respective emissions factors, consistent with the approach used for county facility energy consumption.

Refrigerants

Emissions from the leakage of both mobile and stationary refrigerants within county-owned and/or operated facilities and vehicles were estimated using county-provided data on refrigerant use and/or recharge. These use estimates were converted to greenhouse gas emissions estimates using standard global warming potentials (GWPs) from The GHG Protocol, which are based on findings from the IPCC Sixth Assessment Report (AR6).[16]

[16] IPCC Global Warming Potential (GWP) values relative to CO2 | GHG Protocol

Approach and Data Limitations

While the GHG inventories sought to include the most accurate, locally-specific data available, in some cases data availability was limited and scaling or approximations were necessary. Notable limitations in the data and resulting approaches are summarized below.

Communitywide

Transportation

On-Road Vehicles

- Estimated VMT was split into light, medium, and heavy-duty VMT based on WSDOT HPMS statewide freight percentages. These allocations could deviate from county-level freight percentages.
- Estimated VMT was split into vehicle fuel types based on county-level vehicle registration data (internal combustion engine vs. electric) and state-level data (non-EV fuel type allocation for gasoline, diesel, CNG, and ethanol).

Off-Road Vehicles

- No notable limitations of approach or data sources.

Public Transit

- No notable limitations of approach or data sources.

Aviation

- PDX provided passenger survey data that identified the percentage of departing passengers whose home is Clark County. These data were used to attribute a portion of the airport's 2022 fuel consumption data to Clark County.
- No data received for the following airports: Goheen, Fly for Fun.

Marine

- County-level National Emissions Inventory (NEI) data were used for this analysis, which was last updated in 2020.

Rail

- County-level National Emissions Inventory (NEI) data were used for this analysis, which was last updated in 2020.

Building Energy

Electricity & Natural Gas

- No notable limitations of approach or data sources.

Propane & Fuel Oil

- Downscaled 2022 state-level consumption data from the U.S. Energy Information Administration (EIA) using U.S. Census home heating information and WA employee counts for the county.
- Industrial propane and fuel oil are not included due to limited ability to confidently scale state data to county level.

Industrial Processes

- Emissions from U.S. EPA FLIGHT reporting were used to avoid potential double counting, due to lack of data granularity within WA Department of Ecology reporting (Ecology data does not distinguish emissions by fuel type or application).
- Excluded landfill and stationary combustion emissions to minimize double counting with solid waste and building energy emissions estimates.

Solid Waste and Wastewater

Solid Waste Generation and Disposal

- Landfill: Local waste characterization study not available; used WA Department of Ecology 2020 Statewide Waste Characterization Study, Southwest waste generation area estimates.
- Compost: Compost data were only received from the City of Vancouver.

Wastewater Treatment Processes

- No notable limitations of approach or data sources.

Septic Systems

- No notable limitations of approach or data sources.

Refrigerants

- National-level refrigerant emissions data were scaled to the county-level based on population.

Land Use

Agriculture

- Emissions estimates are not sensitive to local management practices; assume per-unit (e.g., acre, animal) emissions based on national averages.

Tree Loss & Carbon Sequestration

- The most recent year of data available within the LEARN tool at the time of this analysis was 2019, so the tree cover analysis was performed using 2016-2019 to satisfy the tool's three-year analysis time period requirement. The National Land Cover Database (NLCD) used for the LEARN tool's analysis is updated approximately every 2-3 years. Additional information regarding emissions from tree cover loss and carbon sequestration is provided in Appendix D.
- Analysis includes all land use changes within county geographic boundary, regardless of ownership. In some cases, a large proportion of lands within county boundary could be federal- or state- owned or managed lands.

County Government Operations

Built Environment

Facility Electricity & Natural Gas

- No notable limitations of approach or data sources.

Other Facility Energy Sources

- Emissions from this sector are not included in the inventory because data were not available at the time of analysis.

Transportation

On-Road & Off-Road Fleet Vehicles

- No notable limitations of approach or data sources.

Transit Fleet

- No notable limitations of approach or data sources.

Employee Commute

- No notable limitations of approach or data sources.

Business Travel

- No notable limitations of approach or data sources.

Solid Waste & Wastewater

Solid Waste Generation & Disposal

- No notable limitations of approach or data sources.

Landfills

- No notable limitations of approach or data sources.

Wastewater Treatment Processes

- No notable limitations of approach or data sources.

Water Conveyance

- No notable limitations of approach or data sources.

Refrigerants

- No notable limitations of approach or data sources.

Sensitivity to Local Conditions

Not all inventory values are based on locally derived data. Table 9 below summarizes some of the limitations and sensitivities of data used in the communitywide GHG emissions inventory. Generally, GHG estimations in the county government operations GHG inventory reflect locally derived data.

TABLE 9. SUMMARY OF DATA SENSITIVITY TO LOCAL CONDITIONS.

Sector	Values are sensitive to local conditions	Values are sensitive to local conditions, with some exceptions	Values are based on scaled regional/state data	Values are based on scaled national data
Built Environment				
Electricity	✓			
Natural gas	✓			
Fuel oil			✓	
Propane			✓	
Industrial processes	✓			
Transportation				
On-road		✓		
Off-road		✓		
Public transit		✓		
Aviation		✓		
Marine & rail		✓		
Solid Waste and Wastewater				
Solid waste generation & disposal		✓		
Wastewater treatment processes	✓			
Refrigerants				
Refrigerants				✓
Land Use				
Agriculture		✓		
Tree loss	✓			

Appendix B. Emissions Forecast & Scenario Analysis Methodology

Adjusted Business-As-Usual Assumptions

The adjusted business-as-usual (ABAU) scenario included consideration of the following federal, state, and regional policies:

- Washington State Energy Code (SB 5854)
- Washington Clean Buildings Act (HB 1257)
- Federal Vehicle Regulations (CAFE)
- WA Clean Fuel Standard (HB 1091)
- WA Clean Cars Program (SB 5974)
- WA Hydrofluorocarbon Policies (HB 1112 & HB 1050)
- WA Clean Energy Transformation Act (CETA)
- WA Climate Commitment Act (E2SSB 5126)

Additional information regarding policy interpretation and assumptions are provided below.

WA Energy Code (SB 5854)

Interpretation: SB 5854 requires residential and nonresidential construction permitted under the 2031 state energy code to achieve a 70% reduction in annual net energy consumption (compared to a 2006 baseline). State energy codes will be adopted from 2013-2031 to incrementally move towards achieving the 70% reduction by 2031.

Modeling Assumptions: New construction in 2031 and beyond will consume 70% less energy than the 2006 baseline. Scaled 2022 data to 2006 to use a 2006 baseline for this policy analysis. Assumed this baseline applies to all jurisdictions. Using 2022 energy consumption rates, modeled a straight-line reduction in energy consumption rate from 2022 to 2031 to achieve the 70% reduction from baseline (in new buildings only). Assume that any additional energy consumption under BAU compared to 2022 is from new buildings.
All new commercial buildings must use electric heat pumps for space heating and electric water heating for 50% of water (reflects updates to the 2021 WA State Energy Code).

- Assume commercial water heating accounts for 9% of building energy use; assume space heating accounts for 23% of building energy use (total = 32%; Source: EIA 2015).
- Assume 75% of current commercial buildings use fossil fuel space/water heating.

WA Clean Buildings Act (HB 1257)

Interpretation: Requires all new and existing commercial buildings over 50,000 square feet to reduce their energy use intensity by 15%, compared to the 2009–2018 average.

- Buildings greater than 220,000 square feet must comply by June 1, 2026
- Buildings greater than 90,000 square feet must comply by June 1, 2027
- Buildings greater than 50,000 square feet must comply by June 1, 2028

Modeling Assumptions: Using 2022 county level commercial energy consumption data, calculated energy consumed per sq ft of commercial building space to arrive at average energy use intensity (EUI: energy consumed per sq ft). Scaled 2022 data to 2019 as a proxy for 2009-2018 baseline. Modeled a straight-line reduction in energy use intensity (up to 15%) for Bins 1–3 below for 2023 through respective compliance dates.

- Bin 1: >220K sq ft
- Bin 2: > 90K sq ft
- Bin 3: > 50K sq ft
- Bin 4: 50K sq ft and under (rule does not apply)

Federal Vehicle Regulations (CAFE)

Interpretation: Corporate Average Fuel Economy (CAFE) standards are regulated by the DOT and supported by the EPA, calculates average fuel economy levels for manufacturers and sets related GHG standards. Passenger cars and light trucks require an industry-wide fleet average of approximately 49 mpg for passenger cars and light trucks in model year 2026, increasing fuel efficiency 8% annually for model years 2024–2025 and 10% annually for model year 2026. This will also increase the estimated fleetwide average by nearly 10 miles per gallon for model year 2026, relative to model year 2021.

Modeling Assumptions: Based on PSRC Vision 2050 modeling, scaling 2022 data to 2018 for these assumptions, assumed the following changes in vehicle emissions intensity (g CO_2e/mile):

- Light duty vehicles: 33% reduction from 2018 to 2050.
- Heavy duty vehicles: 26% reduction from 2018 to 2050.

WA Clean Fuel Standard (HB 1091)

Interpretation: The Clean Fuel Standard requires a 20% reduction in the carbon intensity of transportation fuels by 2038, compared to a 2017 baseline level. Reductions in carbon intensity may be achieved through cleaner fuels or by purchasing clean fuel credits from cleaner producers such as those providing electricity as fuel. Boats, trains, aircraft, and military vehicles & equipment are excluded.

Modeling Assumptions: Model assumes the 2022 transportation fuel emissions factors are applicable for 2017–2023 (2017 is policy baseline year). Overall, policy calls for 20% reduction in carbon intensity of transportation fuels by 2038.

EV/fuel contributions: Since there are concerns with WA's short-term ability to scale up low carbon fuels, for 2030 the split of clean fuel/EV is closer to 35%/65%, compared to 50%/50% by 2038.

Therefore, compared to baseline, we modeled the following for fuel carbon intensities:

- 3.5% reduction in per-gallon gasoline & diesel vehicle (passenger, heavy duty, transit) emissions from cleaner fuels (NOT EVs) by 2030.
- 10% reduction in per-gallon gasoline & diesel vehicle (passenger, heavy duty, transit) emissions from cleaner fuels (NOT EVs) by 2040.
- Maintain 10% reduction levels to 2050.

Given ICE ban, compared to baseline, we will model the following for EV use:

- 6.5% transition of gasoline/diesel passenger vehicles to EV by 2030.

- 10% transition of gasoline/diesel passenger vehicles to EV by 2040.
- Maintain 10% reduction levels to 2050.

WA Clean Cars Program (SB 5974)

Interpretation: Establishes a target that, "all publicly owned and privately owned passenger and light duty vehicles of model year 2030 or later that are sold, purchased, or registered in Washington state be electric vehicles."

Modeling Assumptions: As part of Move Ahead Washington program, WA would ban sale of gasoline/diesel ICE passenger vehicles starting in 2030. For this policy, assuming a 15-year vehicle turnover rate, with the following proportion of new sales EV (a conservative estimate given that the ICE ban is currently a goal and lacks a clear accountability mechanism):

- 25% by 2026
- 65% by 2030
- 100% by 2035
- Maintained by 100% thereafter

WA Hydrofluorocarbon Policies (HB 1112 & HB 1050)

Interpretation: HB 1112 requires that new equipment be manufactured without HFCs or using refrigerants with a lower global warming potential (GWP) in a phased approach through 2024. Equipment covered by the law are being phased in each year, starting with 2020, and penalties apply for non-compliance. In 2021, HB 1050 applied Clean Air Act provisions for ozone depleting substances to HFCs and extended restrictions on higher GWP HFCs to new equipment such as ice rinks and stationary air conditioning.

Modeling Assumptions: Aligned model assumptions with state modeling, scaling 2022 data to 2019 to align with modeling.

WA Clean Energy Transformation Act (CETA)

Interpretation: CETA applies to all electric utilities serving retail customers in Washington and sets specific milestones: By 2025, utilities must eliminate coal-fired electricity from their state portfolios; by 2030, utilities must be greenhouse gas neutral, with flexibility to use limited amounts of electricity from natural gas if it is offset by other actions; by 2045, utilities must supply Washington customers with electricity that is 100% renewable or non-emitting, with no provision for offsets.

Modeling Assumptions: Electricity will be GHG neutral (electricity emissions factor equals zero) in 2030 and beyond with a straight-line emissions factor reduction from 2022 to 2030. For utilities that rely on coal for electricity generation, additionally model straight-line reduction to 0% coal by December 31, 2025. Assume coal is replaced by renewables. This action impacts electricity emissions factors (reduces emissions per unit of energy consumed).

WA Climate Commitment Act (E2SSB 5126)

Interpretation: The Climate Commitment Act (known as Cap and Invest) places an economy-wide cap on carbon to meet state GHG reduction targets and remain consistent with best available science, while minimizing the use of offsets to meet those targets. Every polluting facility covered under the program needs to hold one allowance for every ton of greenhouse gas that it emits. Based on an environmental justice

review, 35–40% of investments must be made in overburdened communities to reduce health disparities and create environmental benefits, with an additional 10% allocated for tribal programs and projects.

Modeling Assumptions: State estimates that CCA will account for 26.2 million $MTCO_2e$ in statewide reductions by 2030. 2018 total emissions = 99.57 million $MTCO_2e$. Scaled 2022 data to 2018 to obtain a proxy baseline.

Key regulated CCA sectors relevant to the geographic inventory include:

- Natural gas (however, this sector will receive directly allocated no-cost allowances).
- Industrial processes (however, Emissions-Intensive Trade-Exposed facilities will receive directly allocated no-cost allowances).
- Transportation fuels (however, already covered to some extent by Clean Fuels Standard).

Therefore, assume the following for CCA:

- Assume CETA addresses emissions reductions in electricity sector.
- Apply -10% emissions factor adjustment to natural gas (assuming increase in hydrogen or RNG in fuel mix) to 2030.
- Apply -15% emissions reduction estimate (consider applying a reduction factor) to industrial process emissions to 2030.
- Apply -23.5% fuel emissions factor reduction estimate (consider applying a reduction factor) to transportation emissions to 2030 and -30% to 2040 (includes reductions from CFS).

Appendix C: GHG Emission Reduction Policies

This appendix contains examples of greenhouse gas emission reduction policies that could be included within Clark County's Climate Element. These are example goals and policies (measures) drawn from the Department of Commerce's Climate Policy Explorer. Visit the Climate Policy Explorer for additional measures.

How to read these policies:

The list of model goals and policies below is organized principally by applicable climate sectors listed in Commerce's climate element planning guidance and Climate Policy Explorer. These goals and policies align with applicable GHG-reduction strategies from the Emissions Forecast and Scenario Analysis Tool.

Counties may use these optional measures as written, adapt them to fit local context, or supplement them. For example, a county may tailor a policy to reflect its available "levers" and/or appropriate role(s) in achieving a policy's intended outcomes.

Please access details related to listed measures using the Goal and Policy IDs in Climate Policy Explorer. These details provide information on the statutory requirements satisfied by the measures, as well as information about the measures' co-benefits and environmental justice potential that can be used to inform policy development and evaluation for adoption.

For each strategy, information about that strategy's relevant greenhouse gas emissions is provided for context (e.g., 22% of 2022 communitywide emissions). This value—the proportion of the county's 2022 communitywide emissions inventory associated with the strategy's relevant emissions source—provides insight into the potential reduction impact of that strategy. In general, strategies that address large emissions sources may have greater reduction potential than those targeting smaller sources.

Sector: Zoning

Applicable Strategies

Reduce passenger vehicle travel.

21% of Clark County's 2022 communitywide emissions

Reduce industrial emissions.

2% of Clark County's 2022 communitywide emissions

Applicable Goals and Policies

Goal: Foster higher-intensity land uses in mixed-use urban villages and transit corridors. [*Priority Goal ID# C*]

- Ensure public transit stops and stations are located at or near (e.g., within 600 ft.) dense residential, commercial, and employment areas. [*Priority Policy ID# C.01*]
- Implement complimentary, mixed land uses, such as locating businesses, parks and schools, as infill development to reduce driving in urban core areas. [*Priority Policy ID# C.02*]
- Prohibit the expansion of polluting industries in overburdened communities via local zoning and development regulations. [*Priority Policy ID# C.03*]

- Adjust single-family home impact fees and system development charges so those homes with larger impacts on utilities pay more. [*Priority Policy ID# C.04*]
- Limit parking spaces near transit-oriented development to encourage use of transit and decrease single-occupancy vehicle travel. [*Priority Policy ID# C.05*]
- Prioritize infill development through zoning and permitting process. [*Priority Policy ID# C.06*]
- Establish form-based codes where appropriate to better integrate higher-density development. [*Priority Policy ID# C.07*]
- Promote higher density commercial, mixed-use and residential development within commercial nodes along transportation corridors, consistent with Transit Oriented Development guidance. [*Priority Policy ID# C.08*]
- Increase residential densities near (within 0.25 mile) transit stations and centers. [*Priority Policy ID# C.09*]

Goal: Increase housing diversity and supply within urban growth areas to reduce greenhouse gas emissions and support environmental justice. [*Priority Goal ID# K*]

- Increase or remove density limits in areas well-served by transit and other services within the urban growth area. [*Priority Policy ID# K.01*]
- Allow middle housing types, such as duplexes, triplexes, and ADUs, on all residential lots, consistent with RCW 36.70A.635, 680, 681 and 696. [*Priority Policy ID# K.02*]
- Establish minimum residential densities within urban growth areas. [*Policy ID# K.04*]
- Allow or encourage micro-housing units. [*Priority Policy ID# K.05*]
- Develop and implement inclusionary zoning to support greater income diversity in housing types. [*Priority Policy ID# K.06*]
- Plan for and invest in capital facilities to accommodate infill development. [*Policy ID# K.07*]
- Establish minimum residential densities within urban growth areas. [*Policy ID# K.08*]

Sector: Transportation

Applicable Strategies

Reduce passenger vehicle travel.

21% of Clark County's 2022 communitywide emissions

Electrify passenger vehicles.

21% of Clark County's 2022 communitywide emissions

Electrify freight/service vehicles.

9% of Clark County's 2022 communitywide emissions

Applicable Goals and Policies

Goal: Convert public fleets to zero-emission vehicles by [insert target date] and develop supporting infrastructure and programs (e.g., charging stations and dedicated lanes for electric cars and buses). [*Goal ID# H*]

- Convert public fleets to zero-emission vehicles. [*Priority Policy ID# H.01*]

- Provide low-income residents subsidies to purchase, lease, or rent electric vehicles and bicycles. [*Priority Policy ID# H.05*]

Goal: Reduce vehicle miles traveled to achieve greenhouse gas reduction goals. [*Priority Goal ID# I*]

- Implement travel demand management (TDM) programs and strategies. [*Priority Policy ID# I.01*]
- Implement multimodal transportation planning to reduce single-occupancy vehicle dependence and greenhouse gas emissions. [*Priority Policy ID# I.02*]
- Incentivize transit use through reduced fares and other financial benefits, and improving infrastructure, service, and safety. [*Policy ID# I.03*]
- Increase multimodal capacity in coordination with the location of higher-density housing and commercial centers. [*Priority Policy ID# I.04*]
- Prioritize and promote public transit expansion and use through coordination of land use and transportation planning. [*Priority Policy ID# I.05*]
- Create a safe, well-connected, and attractive bicycle and pedestrian transportation network to encourage active transportation. [*Priority Policy ID# I.14*]
- Prioritize, develop, and maintain mobility hubs in transportation-efficient locations — especially in overburdened communities experiencing a scarcity of transportation alternatives. [*Priority Policy ID# I.16*]
- Integrate "Complete Streets" principles into the roadway designs of residential developments. [*Policy ID# I.18*]
- Facilitate the siting of complimentary destinations such as commercial-employment centers, schools or education centers, and residential developments close to a transit stop. [*Priority Policy ID# I.19*]
- Establish micromobility centers wherever plausible (e.g., hubs for shared bikes and scooters). [*Policy ID# I.20*]
- Address active transportation and other multimodal types of transportation options in concurrency programs – both in assessment and mitigation. [*Priority Policy ID# I.22*]
- Prioritize permitting for transit-oriented development (TOD) proposals. [*Priority Policy ID# I.24*]

Goal: Use demand-based methods to reflect the actual cost of existing parking. [*Goal ID# AC*]

- Eliminate parking minimum requirements and establish parking maximums. [*Priority Policy ID# AC.01*]
- Reduce parking requirements where there are multimodal options available. [*Priority Policy ID# AC.02*]

Goal: Expand electric vehicle infrastructure. [*Goal ID# AD]*

- Require electric vehicle charging infrastructure in all new and retrofitted buildings. [*Policy ID# AD.01*]

Goal: Improve the efficiency of transportation system to reduce greenhouse gas emissions. [*Goal ID# AI*]

- Provide signal prioritization for freight vehicles, transit buses, and other heavy-duty vehicles. [*Policy ID# AI.01*]
- Develop dedicated electric-vehicle (EV) lanes on local roads and highways. [*Policy ID# AI.02*]
- Improve transit speed, frequency, coverage, and reliability. [*Priority Policy ID# AI.03*]

Applicable Strategies

Electrify new buildings.

12% of Clark County's 2022 communitywide emissions

Electrify existing buildings.

12% of Clark County's 2022 communitywide emissions

Reduce energy use in existing buildings.

32% of Clark County's 2022 communitywide emissions

Strategy: Increase local solar.

32% of Clark County's 2022 communitywide emissions

Applicable Goals and Policies

Goal: Maximize solar access of site design, where practicable, for new solar-ready residential and commercial buildings. [*Goal ID# G*]

- Direct solar development onto lands identified as having "least conflict" through the Least-Conflict Solar Siting process on the Columbia Plateau. [*Policy ID# G.02*]
- Require solar panels on buildings with large rooftops, as well as within or over parking areas. [*Policy ID# G.03*]

Goal: Prioritize the adaptive reuse of buildings, recognizing the emission-reduction benefits of retaining existing buildings. [*Priority Goal ID# F*]

- Prioritize the preservation and weatherization of housing in overburdened communities, particularly at higher densities, to reduce emissions and increase resilience. [*Priority Policy ID# F.02*]

Goal: Ensure that buildings use renewable energy, conservation, and efficiency technologies and practices to reduce greenhouse gas emissions. [*Priority Goal ID# E*]

- Require zero greenhouse gas emissions features for all new residential and commercial structures. [*Priority Policy ID# E.01*]
- Maximize renewable energy sources for the supply of electricity and heat to new and existing buildings. [*Policy ID# E.02*]
- Retrofit buildings for energy efficiency. [*Priority Policy ID# E.03*]
- Develop local microgrid solar and battery storage facilities in low-impact sites. [*Policy ID# E.04*]
- Phase out natural gas use in existing publicly owned facilities by [insert target date] and retrofit with electric appliances, heat pumps, and water heating. [*Priority Policy ID# E.05*]. *Note: Be advised that I-2066, approved by Washington voters in November 2024, prevents counties, cities, and towns from adopting this policy and other policies that prohibit, penalize or discourage natural gas heating in buildings and appliances and equipment within buildings. Check with your jurisdiction's legal counsel about impacts to your* jurisdiction.

- Require all publicly owned buildings to be powered completely by renewable energy by [insert target date]. [*Policy ID# E.06*]. *Note: Be advised that I-2066, approved by Washington voters in November 2024, prevents counties, cities, and towns from adopting this policy and other policies that prohibit, penalize or discourage natural gas heating in buildings and appliances and equipment within buildings. Check with your jurisdiction's legal counsel about impacts to your jurisdiction.*
- Incentivize green building certification to improve energy and environmental performance. [*Priority Policy ID# E.07*]
- Promote the use of energy-efficient appliances in buildings. [*Policy ID# E.09*]
- Promote the use of energy-efficient boilers in buildings. [*Policy ID# E.10*]
- Establish agreements to procure low-carbon-intensity power supply. [*Priority Policy ID# E.11*]
- Encourage use of Combined Heat and Power (CHP) Systems in new and existing developments. [*Priority Policy ID# E.12*]
- Require energy labeling for new residential buildings. [*Policy ID# E.13*]

Sector: Waste Management

Applicable Strategies

Divert construction and demolition (C&D) materials.

<1% of Clark County's 2022 communitywide emissions

Divert other recyclable and compostable materials.

3% of Clark County's 2022 communitywide emissions

Applicable Goals and Policies:

Goal: Ensure that the community is able to reduce, reuse, and recycle waste materials sustainably. [*Goal ID# X*]

- Develop a program that will enable recycling of all construction and demolition debris by [insert target date]. [*Policy ID# X.02*]
- Increase staff and facility capacity for composting programs to divert [insert percentage] of community organic waste from entering landfills. [*Policy ID# X.03*]
- Reduce municipal solid waste disposed of in landfills by [insert percentage] by [insert target date]. [*Policy ID# X.04*]
- Require methane capture processes from wastewater treatment facilities. [*Policy ID# X.05*]
- Recycle all paper, food, textile, and metal waste by [insert target date]. [*Policy ID# X.06*]
- Minimize carbon emission impacts of building demolition with best available recycling strategies. [*Policy ID# X.07*]
- Develop a local pollution surcharge for large producers of air pollutants, wastewater, and solid waste. [*Policy ID# X.08*]
- Encourage partnerships between food generators, distributors, and aid groups (e.g., food banks and community kitchens) to reduce food waste. [*Priority Policy ID# X.09*]
- Implement monitoring and capture of methane at municipal landfills. [*Policy ID# X.10*]

Goal: Develop targeted campaigns for recycling material with highest GHG reduction impact (e.g., paper, metal, food waste). [*Goal ID# D*]

- Incentivize recycling of construction and demolition debris. [*Policy ID# D.01*]
- Create and sustain a business technical assistance program to increase recycling and reduce waste. [*Policy ID# D.02*]

Sector: Agriculture & Food Systems

Applicable Strategies

Decarbonize off-road equipment.

4% of Clark County's 2022 communitywide emissions

Improve soil management.

<1% of Clark County's 2022 communitywide emissions

Protect land carbon sinks (including agricultural lands, wetlands, and grasslands).

2022 annual sequestration amount was equivalent to 24% of Clark County's 2022 communitywide emissions.

Applicable Goals and Policies

Goal: Reduce GHG emissions in rural areas of the county. [*Goal ID# Z*]

- Assess the capacity for transfer of development rights (TDR) and open space or agricultural land preservation programs in the context increasing residential density. [*Policy ID# Z.01*]
- Require methane collection on dairy farms and other agricultural operations that utilize waste ponds to decrease greenhouse gas emissions. [*Policy ID# Z.02*]
- Promote the sale and use of agricultural supplies, pesticides, fertilizers, and fuels that are not derived from fossil fuels. [Priority *Policy ID# Z.04*]
- Phase out the use of municipal gas-powered landscaping equipment and replace with electric or otherwise sustainable alternatives. [*Policy ID# Z.05*]
- Support the installation of anaerobic digesters to manage agriculture and food waste. [*Policy ID# Z.07*]
- Support mass timber manufacturing in rural communities near overstocked forests. [*Priority Policy ID# Z.08*]

Goal: Support long-term local and regional agriculture that sequesters carbon. [*Goal ID# B*]

- Maximize conservation and carbon sequestration through alignment of Conservation Futures, Transfer of Development Rights (TDR), and Open Space Program strategies. [Priority *Policy ID# B.01*]
- Facilitate and enable regenerative agriculture and regenerative ocean farming where practicable. [*Policy ID# B.02*]
- Designate a percentage of agricultural land that shall be maintained and managed for sequestering carbon and curtailing vehicle miles traveled. [*Policy ID# B.03*]

Goal: Preserve land for long-term agricultural use, recreation, open spaces, and other uses consistent with rural character. [*Goal ID# J*]

- Preserve land outside of the unincorporated UGA for long-term agricultural use, recreation, open spaces, forestry, mineral resources, and other uses consistent with rural character. [*Policy ID# J.01*]
- Support funding to protect agricultural land from conversion to other uses, and assist farmers in transferring and accessing land [*Policy ID# J.04*]

Sector: Ecosystems

Applicable Strategies

Reduce tree loss.

16% of Clark County's 2022 communitywide emissions

Protect land carbon sinks (including agricultural lands, wetlands, and grasslands).

2022 annual sequestration amount was equivalent to 24% of Clark County's 2022 communitywide emissions.

Applicable Goals and Policies

Goal: Increase tree canopy cover to boost carbon sequestration, reduce heat islands, and improve air quality, prioritizing overburdened communities. [*Priority Goal ID# AB*]

- Require open space set-asides (such as parks) for new development. [*Policy ID# AB.01*]
- Establish a green belt of parks to support connectivity and non-motorized travel between housing, schools, and businesses across a community. [*Priority Policy ID# AB.02*]
- Improve urban forest management to maximize climate resilience and carbon storage. [*Priority Policy ID# AB.03*]
- Maximize green design in surface parking lots such as tree canopy coverage, permeable pavement, and vegetated strips. [*Priority Policy ID# AB.04*]
- Maintain and manage natural lands (forests, grasslands, wetlands) to maintain or increase their carbon concentrations and avoid conversion of carbon-rich ecosystems. [*Policy ID# AB.05*]
- Maintain small forestland ownership and publicly owned forest properties with carbon sequestration as the goal. [*Policy ID# AB.06*]

Appendix D: Tree Canopy GHG Emissions & Sequestration Summary Report

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Summary Report

GHG Inventory for Forests and Trees Outside Forests, 2016 to 2019

Clark County, Washington

Summary

Forests and trees play a key role in mitigating climate change, yet they are often not included in local greenhouse gas (GHG) inventories or climate action plans. Clark County, Washington has taken the first step towards understanding how local changes in land use and tree canopy have contributed to the county's net greenhouse gas profile. Unlike other sectors, land use (in this case, forests and trees) not only emit GHGs, they also remove CO2 from the atmosphere through photosynthesis, and play a critical role in regulating the planet's climate. The information contained in this summary report can be useful when designing climate actions that reduce GHG emissions and/or increase removals of GHGs from the atmosphere.

Key findings:

- Over the period 2016 to 2019, emissions from forests and trees were 795,522 t CO2e per year.

- Over the period 2016 to 2019, the Net GHG balance of forests and trees was -360,699 t CO2e per year.

- Roughly 42% of Clark County's total land base of 169,843 hectares (419,691 acres) is forest. Many areas outside of forests are also covered by trees, including an average of nearly 15.3 percent tree canopy on lands outside of forest areas

- Over the same period, annual CO2 removals from forests and trees were -1,156,221 t CO2e per year. (Carbon removals are represented by negative values.)

- Total GHG emissions for Clark County across all sectors could be reduced if additional forests/trees were added to its land base, and/or if losses of trees were reduced further.

Table 1. Clark county' s GHG fluxes from forests and trees for inventory period 2016 – 2019, all values reported in t CO2e per year

	Removals(t CO2e/yr)	Emissions(t CO2e/yr)
Undisturbed Forest	-892,732	
Forest Disturbances		259,060
Non-Forest to Forest	-109,446	
Forest to Settlement		9,122
Forest to Grassland		307,661
Forest to other non-forest lands		1,889
Trees outside of forests	-154,042	217,790
Harvested Wood Products	0	
TOTAL	-1,156,221	795,522
Net GHG balance	**-360,699**	

Data Inputs

Data used as inputs into the GHG emission and removal calculations are described below.

Land and Forest Cover

GHG inventories for lands are reported in six “land use” categories which were defined by data on land cover—forest land, grassland, cropland, wetland, settlement and other land (barren, snow, ice). Clark County’s total land base is approximately 169,843 hectares (419,692 acres), with nearly 28.5% Settlement (i.e. developed areas of varying intensity), around 41.7% forest, 23.3% Grassland (which includes hay/pasture, shrub/scrub and other herbaceous cover), 0.4% cropland, 6% wetland and 0.1% other land.

Figure 1. Land cover in Clark from the National Land Cover Database, 2019

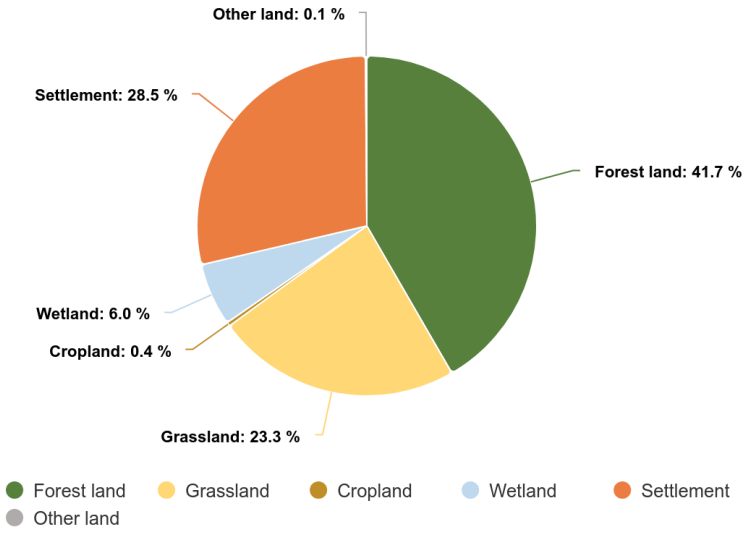
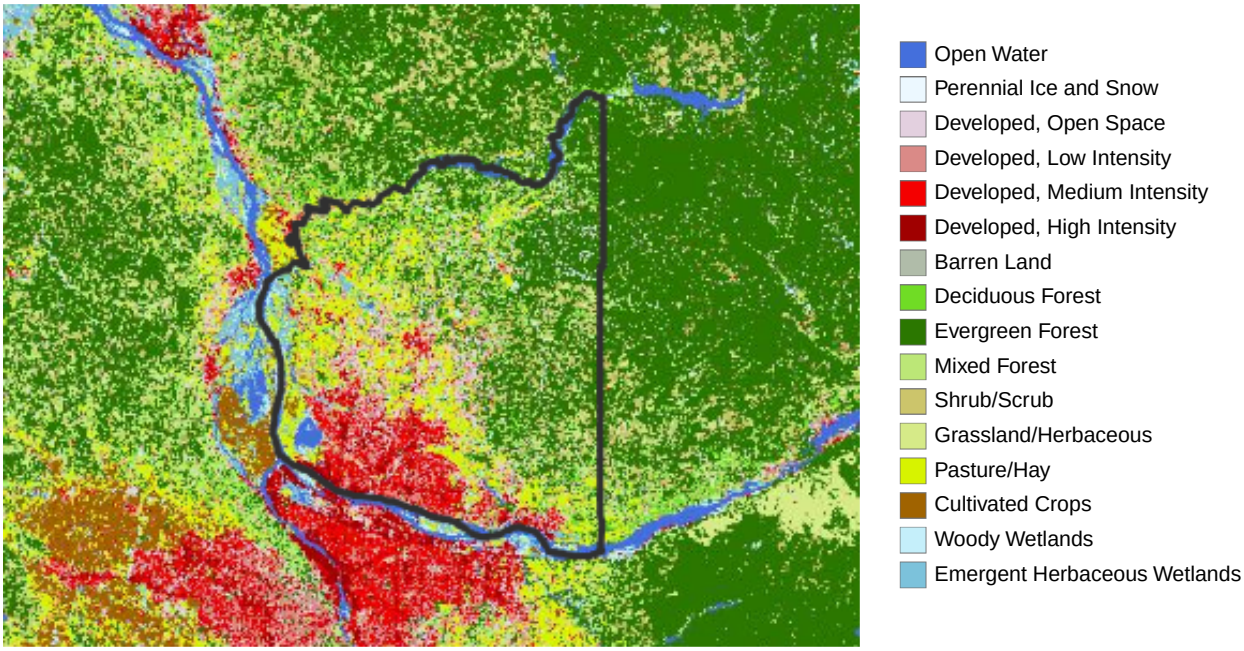


Figure 2. Land cover in Clark from the National Land Cover Database, 2019



Forest Cover Change

Generating GHG estimates requires data not just on areas of land use, but also data on how land use has changed over time. Between 2016 and 2019, the county lost around 1,998 hectares (4,937 acres) of forest land, largely conversion to Grassland. Over the same period, the county gained around 8,780 hectares (21,697 acres) of forest land, largely from Grassland.

Figure 3. Loss of forest to other land use types between 2016 and 2019 (ha)

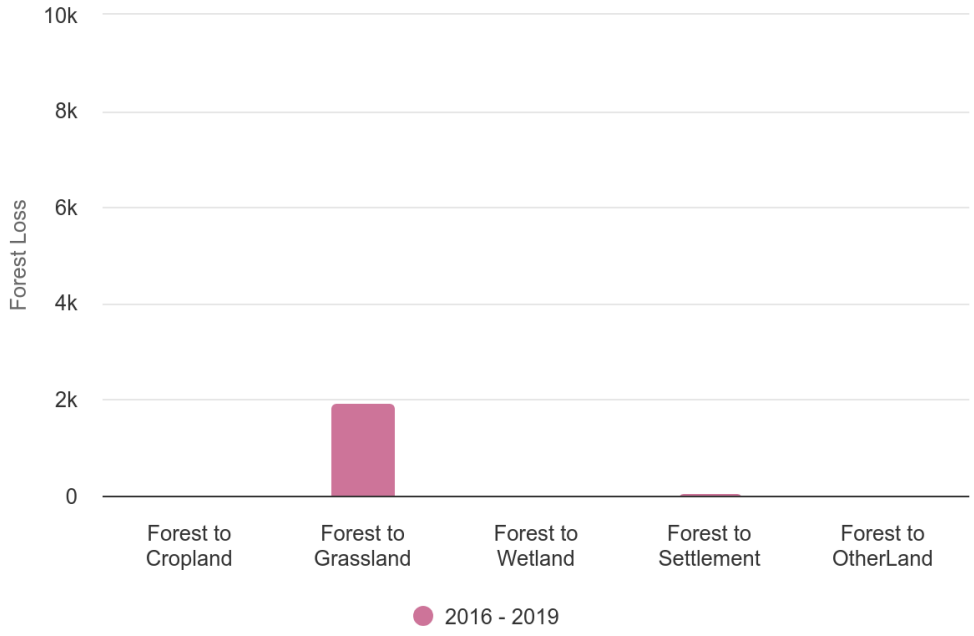
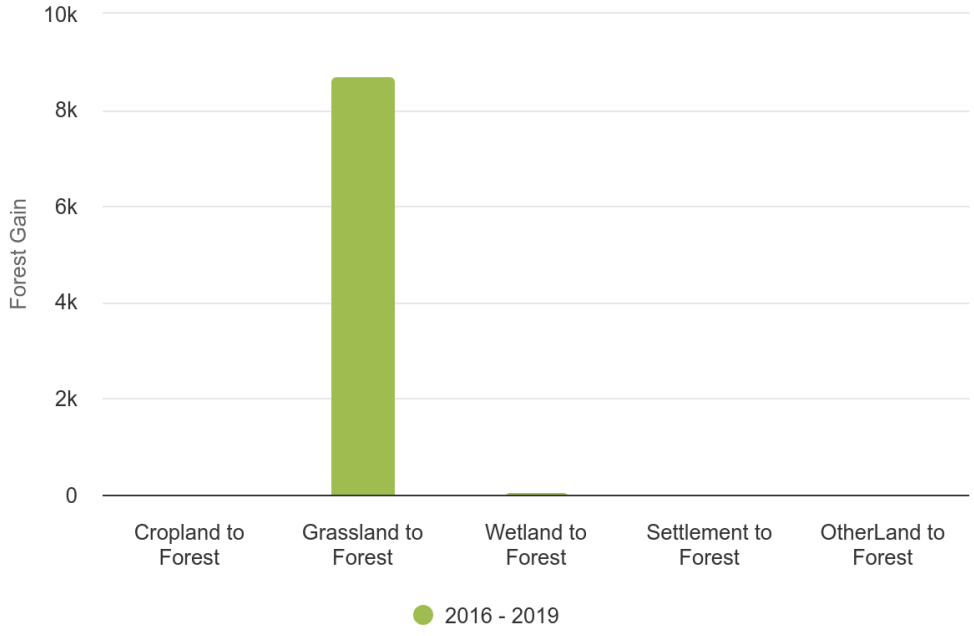


Figure 4. Gain of forest from other land use types between 2016 and 2019 (ha)



Forest Disturbances

Over the inventory period 2016 to 2019, forest disturbance from harvests/other disturbance was the most significant in Clark County, affecting 1308.4 hectares (3233.1 acres), followed by insects, which affected 764.8 hectares (1889.9 acres) and fires, which affected 0 hectares (0.0 acres).

Trees Outside Forests

Figure 5 shows tree canopy captured by the NLCD tree canopy data. (Note that some areas with high tree canopy in Figure 5 overlap with the NLCD forest class shown in Figure 2.)

This data is only available for the years 2011 and 2016. Over this time period, Clark County had an average of 14,884 hectares (36,780 acres) of tree canopy outside forests. Between 2011 and 2016, 619 hectares per year of tree canopy were lost, for a total of 3,094 hectares (7,646 acres) of tree canopy loss over the 5 year period. Most of this loss occurred within the Grassland class.

Figure 5. Tree canopy 2016 (Source: National Land Cover Database)

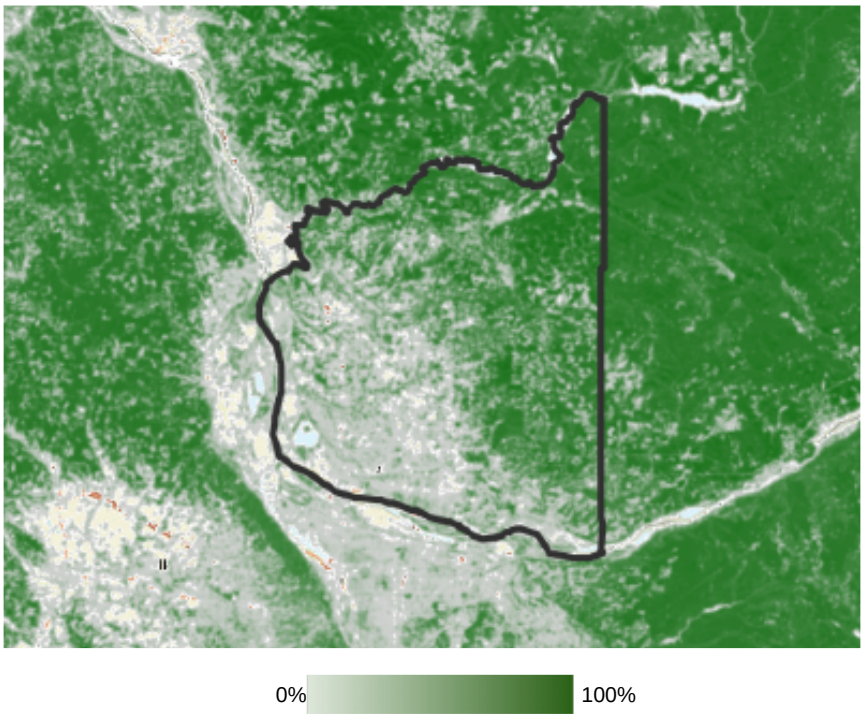


Figure 6: Average tree canopy (in hectares) and % tree canopy in different non-forest land use categories in Clark County for the period 2011-2016. Note: bars relate to tree canopy area (left vertical-axis, hectares) and dots are the % tree cover per land use category (right vertical-axis). “Other” category not shown due to very low area.

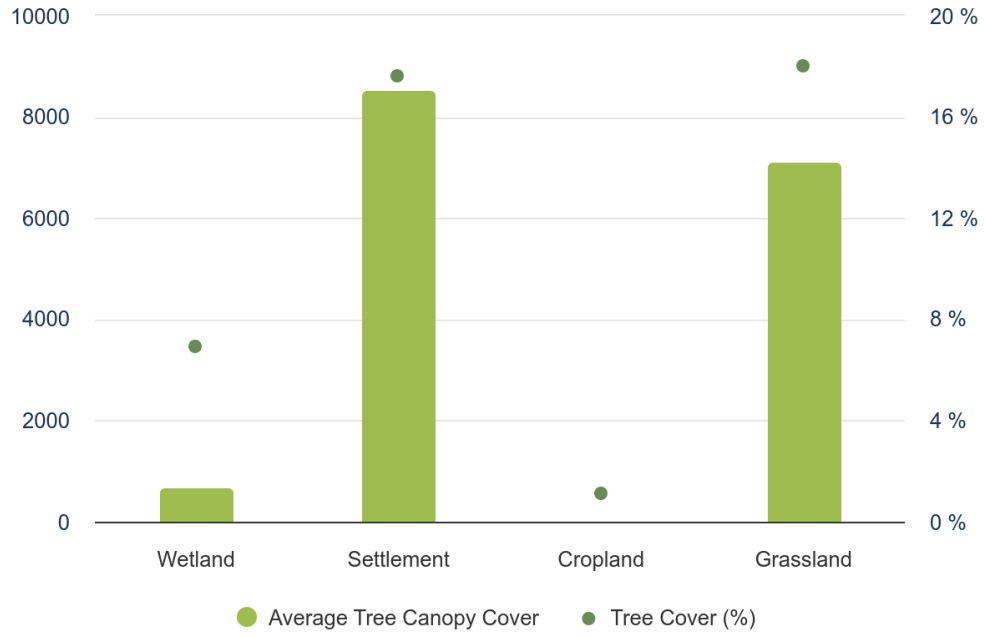
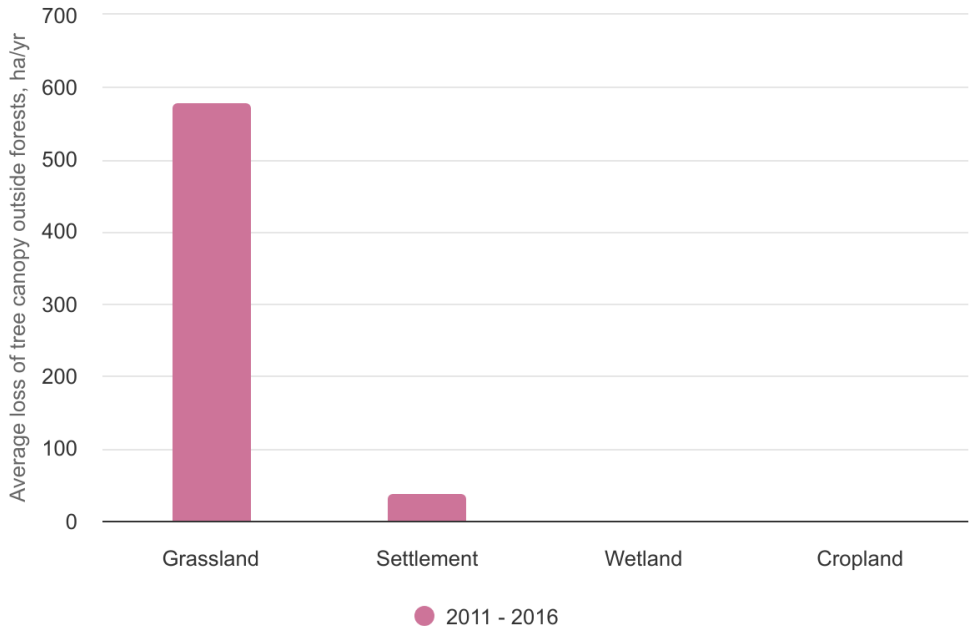


Figure 7: Average area of tree canopy loss in different non-forest land use categories in Clark County over the period 2011 to 2016 (hectares per year). Note: other category not shown due to very low area.



Land Cover Change Matrix

Table 2. Full NLCD land cover change matrix for 2016 to 2019. All areas are in hectares.

2019: Top 2016: Left	Deciduous Forest	Evergreen Forest	Mixed Forest	Woody Wetlands	Cultivated Crops	Pasture/Hay	Grassland/Herbaceous	Shrub/Scrub	Open Water	Emergent Herbaceous Wetlands	Developed, Open Space	Developed, Low Intensity	Developed, Medium Intensity	Developed, High Intensity	Barren Land	Perennial Ice/Snow	Total
Deciduous Forest	8,863	0.1	0	0	0	1	189	7	0	0	10	4	2	0.3	0.7	0	9,077
Evergreen Forest	0	37,538	0.1	0	0	5	1,304	53	0.5	0	12	5	3	1	2	0	38,923
Mixed Forest	0	0.1	10,429	0	0	0	359	11	0.1	0	6	2	0.7	0	2	0	10,810
Woody Wetlands	0	0	0	5,148	0	0	0.2	0	2	5	5	3	2	0.4	0	0	5,165
Cultivated Crops	0	0	0	0.7	650	0	0	0	1	0	2	2	2	2	0	0	660
Pasture/Hay	1	2	0.5	3	2	26,978	0.9	0.7	10	1	103	96	93	49	0.5	0	27,340
Grassland/Herbaceous	0	8	0	0	0	9	1,171	4,783	2	0	11	12	17	4	8	0	6,026
Shrub/Scrub	10	8,509	179	0	0	12	46	4,697	0.7	0	9	4	2	2	3	0	13,474
Open Water	0	0.3	0	0.1	0	0	0.6	0	6,780	3	0.4	0.3	0.3	0.1	2	0	6,788
Emergent Herbaceous Wetlands	0	0	0	68	0	0	0.3	0	51	3,238	2	1	0.9	0.2	0	0	3,360
Developed, Open Space	0	0	0	0	0	0	0	0	0	0	16,557	38	190	60	0	0	16,845
Developed, Low Intensity	0	0	0	0	0	0	0	0	0	0	0	16,054	88	91	0	0	16,233
Developed, Medium Intensity	0	0	0	0	0	0	0	0	0	0	0	0	11,440	8	0	0	11,448
Developed, High Intensity	0	0	0	0	0	0	0	0	0	0	0	0	0	3,493	0	0	3,493
Barren Land	0	0.2	0	0	0	0	5	0	20	0	0.2	0.4	0.3	0.3	179	0	205
Perennial Ice/Snow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**8,874**	**46,057**	**10,608**	**5,218**	**652**	**27,005**	**3,076**	**9,551**	**6,867**	**3,246**	**16,717**	**16,222**	**11,842**	**3,711**	**198**	**0**	**0**

Table 3. Simplified land cover change matrix for 2016 to 2019.All areas are in hectares.

2019: Top 2016: Left	Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	Total
Forest Land	61,978	0	1,930	7	56	5	**63,976**
Cropland	0.7	650	0	1	8	0	**660**
Grassland	8,712	2	37,697	13	404	12	**46,839**
Wetland	68	0	0.9	10,072	5	2	**10,148**
Settlement	0	0	0	0	48,018	0	**48,018**
Other Land	0.2	0	5	20	1	179	**205**
Total	**70,758**	**652**	**39,632**	**10,114**	**48,492**	**198**	**0**

Emission and Removal Factors

A summary of the emission and removal factors used in the calculations is provided in Table 4.

	Emission Factor (t C/ha)	Removal Factor (t C/ha/yr)
Forest Change		
Deforestation		
To Cropland	0.00	
To Grassland	130.33	
To Settlement	132.99	
To Wetland	82.82	
To Other	202.47	
Reforestation (Non-Forest to Forest)		-3.40
Forest Remaining Forest		
Undisturbed		-4.06
Disturbed		
Fire	0	
Insect/Disease	-17.25	
Harvest/Other	171.93	
Trees Outside Forest		
Tree canopy loss	95.90	
Canopy maintained/gained		-2.82

Harvested Wood Products

Harvested wood products (HWP) temporarily store carbon from the forest ecosystem as the wood goes through a series of production processes and end-uses, with eventual disposal (and emission to the atmosphere). The delay represents a net benefit to the atmosphere. The period of storage varies from long-lived solid wood products that remain in use for long periods of time to products that are quickly disposed of in landfills.

In the web tool, the HWP Calculator tracks carbon in harvested wood through four different “fates,” from harvest to timber products to primary wood products to end-use to disposal, applying best estimates for product ratios and half-lives at each stage. Based on user inputs entered about annual harvest volumes in Clark County, the change in the harvested wood pool over the inventory period 2016 to 2019 is estimated as 0 t CO2e per year.

Caveats

Information presented here represents a snapshot in time of the net GHG balance and many of the factors contributing to that balance. The estimates can help identify where policies may be designed to reduce net GHG emissions. This inventory currently uses a simplifying assumption that a loss of forest or trees results in immediate emissions to the atmosphere (rather than delayed emissions in the case of various use cases from long-term storage to shorter decay timelines if sent to landfills). In general, it is important to consider that these estimates represent a relatively short period of time compared with the long-term consequences of policy decisions and land management actions. For example, a forest converted to settlement represents a permanent loss of removal capacity. Over the long term, maintaining forests will sustain a higher rate of carbon removal, depending on age-related growth rates and occurrence of disturbances.

There are significant uncertainties in the estimates. Although not quantified here, typical greenhouse gas inventories of forests using similar approaches, including the national GHG inventory, report uncertainties in the net GHG balance that can be as high as ±45% (with 95% confidence). In the results presented here, the most uncertain estimates involve emissions from land-use change which are based on well-documented remote-sensing products, but relatively few field observations from a statistical sampling of county forests. While uncertainties can be high, the estimates can still provide useful information on the relative magnitude and importance of such GHGs; subsequent analyses can also provide information on the directionality of emissions and removals from land management.

Finally, it is recommended that additional analyses be done using models that project impacts of alternatives over coming decades. Such models are available and have been used in other studies at county scale. The GHG inventory presented here is only the first step to providing science-based information to support policy decisions. To more fully explore the potential impacts of alternate policies, projection models can be used to compare long-term results among the alternatives which typically include a “business as usual” (i.e. no change in policy) alternative. This feature may be added into the web tool in the future.

Appendix E: StreetLight Data Methodology

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STREETLIGHT InSight

SB 743 VMT Metric Methodology and Validation White Paper

Version 1.1

December 2021

STREETLIGHT

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Introduction

This technical document describes the data sources, methodology, and validation processes used by StreetLight Data to develop a set of VMT measurements (our SB 743 Metric) to address California Senate Bill 743. As a result of SB 743, there are many applications for our Metric, however we developed this Metric with two specific use cases in mind: screening projects (streamlined review for residential and office projects located in low VMT generating areas); and analyzing comparable sites (trip generation, trip length, and VMT estimation for comparable sites to estimate VMT generation for your own site). We expect many more use cases to come out of SB 743 and we invite you to share other examples and applications for this Metric, along with requests for any new data products that may emerge. This document will be updated as the Metric evolves and adapts to meet the needs of organizations fulfilling the goals of SB 743 and environmental impact analysis compliance.

Background on California SB 743 and Data Needs

California Senate Bill 743 (SB 743) was signed in 2013 and later incorporated into the California Environmental Quality Act (CEQA) in 2018. Starting July 1, 2020, all new land-use development and transportation projects will be expected to evaluate transportation impacts under CEQA using vehicle miles traveled (VMT) instead of Level of Service (LOS). While LOS requires the estimation of traffic volumes on the roadway, typically conducted by manual surveys or tube counts, calculating baseline VMT for SB 743 requires data on the amount of vehicle trips, trip lengths, and vehicle occupant classification (resident vs. employee).

Unfortunately, traditional data collection methods cannot provide the nuanced details needed to comply with SB 743—the length of entire trips or the classification of a vehicle as a resident or employee of the area—at a reasonable cost. Instead, planners typically turn to local travel demand models which are based on periodic household or employer travel surveys. When it comes to estimating VMT with models, there are some limitations:

- Surveys are expensive, time consuming, and respondents may suffer from recall biases.
- Models are computationally expensive as well as technically difficult to manage.
- Models are geographically constrained, and depreciate in accuracy as the model approaches regional boundaries.
- Most models are aggregated to a geography such as TAZ, making them unable to capture local behavioral nuances.
- Models are updated infrequently and rely on outdated travel surveys.
- Models expand from a relatively low sample size and limited geographies, especially in non-urban communities.

Travel demand models perform a crucial role in land-use scenario planning, and they also offer a solution for estimating macro-level VMT trends. However, due to the stringent specifications of SB 743, developers, planners, and policy makers need granular, up-to-date VMT estimates with more precision.

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The Locational Data Approach to VMT

The CEQA Guidelines and previous case law have raised expectations for lead agencies performing technical analysis to use the "best available data." Extending this expectation to VMT spotlights some limitations in using travel demand models, especially those developed for regional applications (i.e., MPO models). Travel demand models are equipped to simulate regional trends, they often lack the nuances of local travel patterns due to the sparseness of the household travel surveys that underpin them. For VMT estimation, Location Based Data (LBS) serves as a powerful alternative for the following reasons:

- Estimations are based on a large sample size that can cover 365 days a year.
- Trips are tracked from start to finish with no boundaries.
- Trips in different geographic regions can be compared apples-to-apples, without concern for whether the underlying survey data is dissimilar.
- The region of analysis can be as small (parcel) or as large (county, MPO) as desired.
- StreetLight's Metric is updated every month.
- StreetLight has historical data from the last few years, allowing for temporal comparisons.

While LBS is not a perfect source (it still relies on a sample which is subject to sampling biases, privacy restriction, etc.), it is superior to regional travel demand models in estimating granular VMT patterns especially for individual land use types, trip purposes, and vehicle occupants because of its large sample size and historical availability.

Development of StreetLight's SB 743 Metric

Following SB 743's ratification in 2013, the California's Governor's Office of Planning and Research (OPR) developed a technical advisory to outline the important questions to be answered in VMT estimation and impact analysis. We designed our SB 743 Metric specifically to meet the expectations outlined in OPR's technical advisory.

The policy goal for SB 743 is to reduce greenhouse gas emissions and other environmental impacts by quantifying and mitigating VMT that results from new developments. Since developments take many forms, central in the technical advisory's recommendation is that VMT should not be measured by a single factor. Instead, VMT calculations, to the extent possible, should account for the full length of vehicle trips, the occupant (i.e., resident, worker, or visitor), and the purpose of the trip. VMT reporting segmented along these lines will allow planners to articulate the impacts of new developments more precisely.

Methodology for Measuring SB 743 with Locational Data

The following are the steps that we take to ingest LBS data and produce our SB 743 VMT Metric in accordance with OPR guidelines.

STEP 1: GET TRIPS

First, we retrieve a set of trips from the billions of trips in our repository for a specific data period and geography. Trips are created using anonymized locational records, passively collected from smart phones, and grouped into key patterns. (see this link for our standard methodology document)

STEP 2: ASSIGN TRIPS TO RESIDENCE STATUS

From these travel patterns, we can infer probable home and work locations for composite groups of people. 'Home' and 'Work' locations are determined based on the frequency of daytime and nighttime hours of the devices responsible for the trips and land use (contact your StreetLight representative for more details on our Home and Work locations methodology.) In each zone, devices with home or work locations in that Block Group are considered 'Residents' or 'Workers,' respectively. All other devices are considered 'Visitors.'

STEP 3: ASSIGN TRIPS TO PURPOSES

Trip origins and destinations are sorted into 'Home,' 'Work,' or 'Other' based on proximity to that device's home and work locations. Next, the trips are distributed to their appropriate trip purpose bin, as demonstrated in Figure 1.

	Home-to-Work (H2W)	Work-to-Home (W2H)	Home-to-Other (H2O)	Other-to-Home (O2H)	Work-to-Other (W2O)	Other-to-Work (O2W)	Other-to-Other (O2O)
Resident VMT							
Employee VMT							
Visitor VMT	n/a	n/a					

Figure 1: SB 743 requires trips be segmented by trip purpose and residence classification. The table above demonstrates the possible combinations trips are sorted into. N/A's exist because if a trip started or ended at a home or work location, the device cannot be classified as a visitor.

It's important to note that the OPR technical advisory recommends inter-regional trips to be counted in both the origin region and the destination region.

STEP 4: AVERAGE TRIP LENGTH

Next, we calculate the average trip length and the volume of trips for each combination of residence status and trip purpose.

STEP 5: CALCULATE VMT PER DEVICE-DAY

After trips have been assigned and expanded to real-world estimations, the next step is to normalize VMT per device-day. Residence VMT and Employee VMT are divided by the number of days residents[1] and employees[2] devices are active, respectively.

STEP 6: SUMMARIZE BASED ON OPR CLASSIFICATIONS

Finally, in order to apply our Metric to proposed developments, we summarize the VMT/Device-Days based on OPR's recommendations for VMT classifications, visualized in Figure 2.

	H2W	W2H	H2O	O2H	W2O	O2W	O2O
Resident VMT							
Employee VMT							
Visitor VMT	n/a	n/a					

Figure 2: The table above is color coded to indicate our relevant Metrics for assessing residential and commercial developments. Impact of employees is assessed based on their trips to and from work. Impact of Residents are assessed based on all trips to or from home.

These classifications are important because our VMT estimations can be used for mixed-use development projects, such as ones with 200 residents and 50 employees. OPR partnered with a handful of expert stakeholders to develop this technique using 5 case studies as examples.

STEP 7 (OPTIONAL): OBTAIN REGIONAL COMPARISONS FOR A SCREENING MAP

One specific application OPR calls for is a screening application to determine if a proposed development location is in an area of 'less than significant impact.' The assessment area, a Block Group for example, is compared against the City, County, and MPO VMT averages. To calculate regional VMT averages, we take the product sum for all of the sub-geographies. Since inter-regional trips may be counted as 'resident' in the origin region but 'employee' in the destination region, it's important to summarize each residence status separately, in order to avoid double-counting these trips.

Validation of Our SB 743 VMT Metric

Fehr & Peers (F&P), a consulting firm, performed an independent validation of our results. In the validation, F&P compared our SB 743 Metric to results from the Sacramento Council of Government (SACOG)'s Activity Based Model, SACSIM. SACSIM synthesizes region-wide daily travel patterns collected from their household survey done in 2018. SACOG has one of the most robust survey/demand model processes, and a very diverse set of communities and land uses, making it a good candidate for validation. Placer County was selected as the specific jurisdiction for comparison.

[1] For the number of residents, we used the American Community Survey data source (ACS, 2018)
[2] For the number of employees, we used the Longitudinal Employer-Household Dynamics data source (LEHD, 2017)

F&P first validated the trips by looking at the 'resident' trip volumes, segmented by trip purpose. They only compared resident trips to align with the survey's methodology. As demonstrated in Figure 3 below, StreetLight's results fell within .5% on resident home-based trips counts.

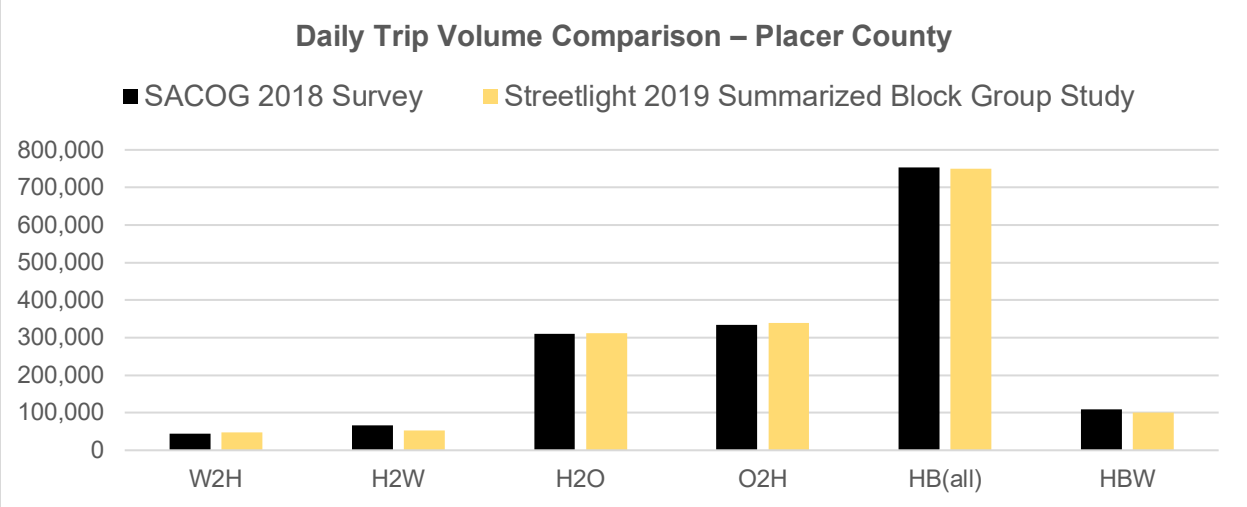


Figure 3: Comparison of daily trip volume by purpose for residents of Placer County.

Next, F&P compared the second component of VMT, average trip length, against the survey results. Similar to the first validation, they compared trip lengths across Placer County for each trip purpose. Shown in Figure 4 below, average trip lengths also had a close alignment between each trip purpose. Work-related trips had the closest matches, while StreetLight estimates of home-based trip purpose trip lengths was generally higher. This is due to the exclusion of vehicle trips under 500 meters in the StreetLight estimates, as a part of our trip creation criteria – thus, StreetLight has 18% of vehicle trips under two miles whereas the SACSIM model had 36% of vehicle trips under two miles (see this link for our standard methodology document for more details on trip creation), which has a big impact on average. Another potential factor is that the StreetLight Metric represents weekdays throughout the year and would capture long-distance vacation and recreational trips leaving or returning to home and that do not occur on a routine basis and are not captured in conventional household travel surveys or the SACSIM model.

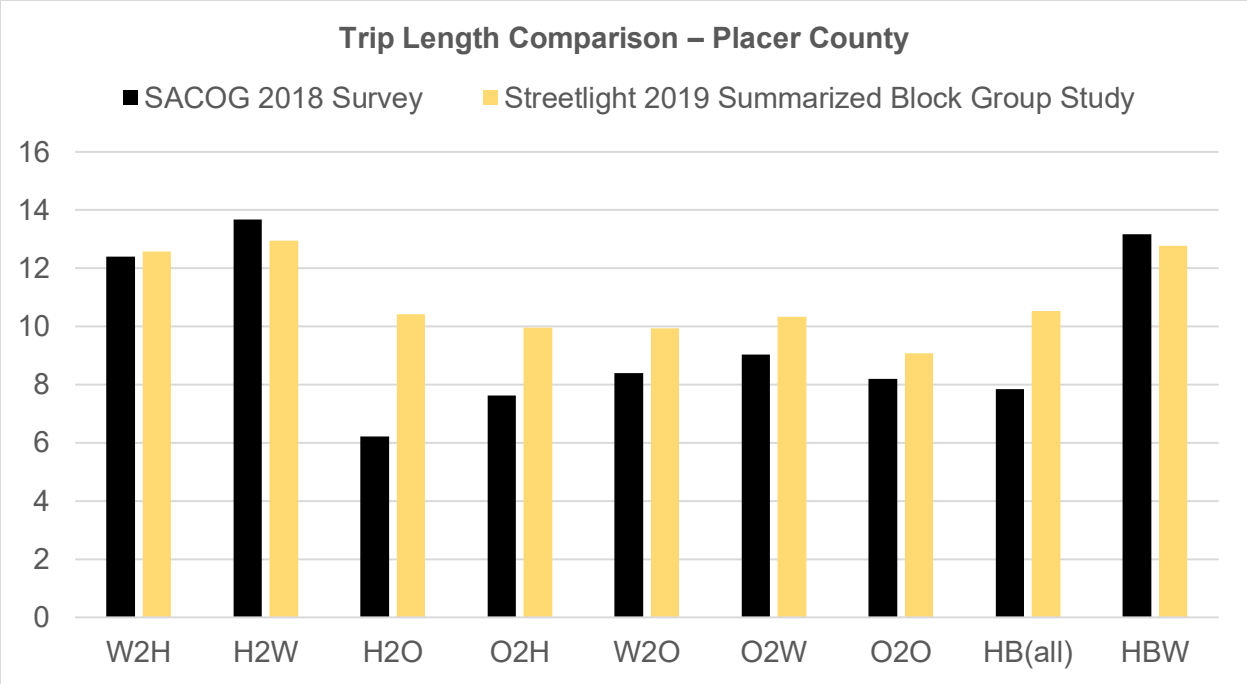


Figure 4: Comparison of average trip lengths by purpose for residents of Placer County. StreetLight's longer "other" purposes are partially a result of our inclusion of the full trip when trips cross model boundaries (for example, Bay Area residents driving to Sacramento region).

After, F&P compared our Metric to SACSIM under two different settings at smaller geographic resolution. Figure 5 below shows the impact on VMT when trips outside a model's boundary are excluded. Additionally, it demonstrates the close alignment of our results, which don't have geographic and temporal boundaries.

StreetLight and SACSIM VMT per Resident Comparison			
Jurisdiction	**SACSIM 2016 Excluding IX/XI[3]**	**SACSIM 2016 Including IX/XI[4]**	**StreetLight 2019**
Auburn	13.97	21.63	20.52
Lincoln	17.49	22.58	19.63
Rocklin	12.78	17.77	18.92
Roseville	12.13	17.18	16.75
Placer County	15.71	21.29	21.47

Figure 5: Comparison of average VMT per resident in five Placer County cities, according to SACSIM and StreetLight. The difference between SACSIM and StreetLight shows the impact on VMT when trips outside a model's boundary are excluded.

[3] Excludes internal-external (IX) and external-internal (XI) trips and trip lengths outside model boundary.
[4] Total VMT per resident—Includes non-home-based trips plus internal-external (IX) and external-internal (XI) trips. Excludes trip length outside model boundary

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Overall, Fehr &Peers found our results comparable, and followed up in their quantitative investigation by demonstrating multiple development locations where our results picked up on local travel patterns that SACSIM missed. In Figure 6 below, F&P demonstrates how our results more accurately identified areas of lower average VMT in a small, dense development compared to SACSIM.

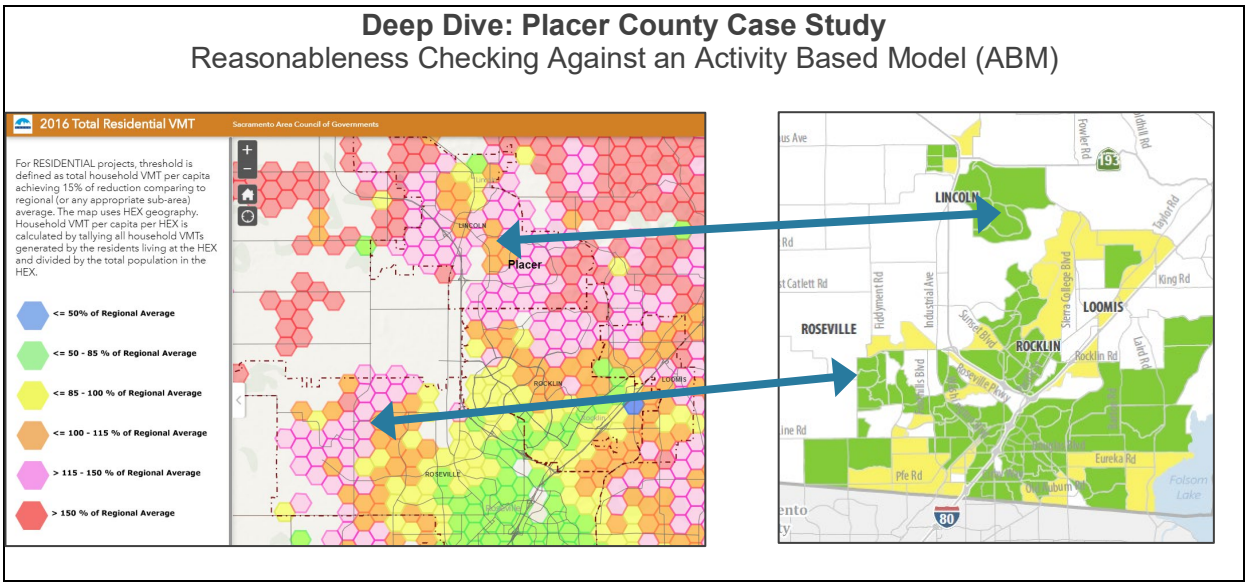


Figure 6: Comparison of SACSIM (left) and StreetLight (right) demonstrates how StreetLight's Metric correctly identified the influence of 'age qualified' housing (i.e., only 55 or over), which generates vehicle trips at about one-third the rate of surrounding single-family homes, resulting in lower average VMT.

Find more examples of F&P's validation, and the rest of the slides from the joint webinar here.

Conclusion

StreetLight's VMT Metric is an easy and affordable way to get SB 743 compliant VMT data anywhere in the state. This data can be used for screening, direct VMT estimation, and for mitigation monitoring over time. Transitioning to VMT is a big difference in how California thinks about impacts of development – not just "to drivers" but "of driving" – and we want to equip organizations with accurate, repeatable metrics to easily respond to the transition from LOS to VMT. Since SB 743 is new legislation, as more organizations and agencies use this Metric to satisfy the new requirements, we may improve our methodology as time moves forward and the needs of the community evolve.

About StreetLight Data

StreetLight Data, Inc. pioneered the use of Big Data analytics to help transportation professionals solve their biggest problems. Applying proprietary machine-learning algorithms to over 100 billion location data points every month, StreetLight measures multimodal travel patterns and makes them available on-demand via the world's first SaaS platform for mobility, StreetLight InSight®. From identifying sources of congestion to optimizing new infrastructure to planning for autonomous vehicles, StreetLight powers more than 10,000 projects every month.

Acknowledgements

We'd like to thank Fehr & Peers for contributing to this white paper, along with providing guidance and industry expertise as we developed the white paper.

Appendix

Example Scenario: Device home & work located in different Block Groups

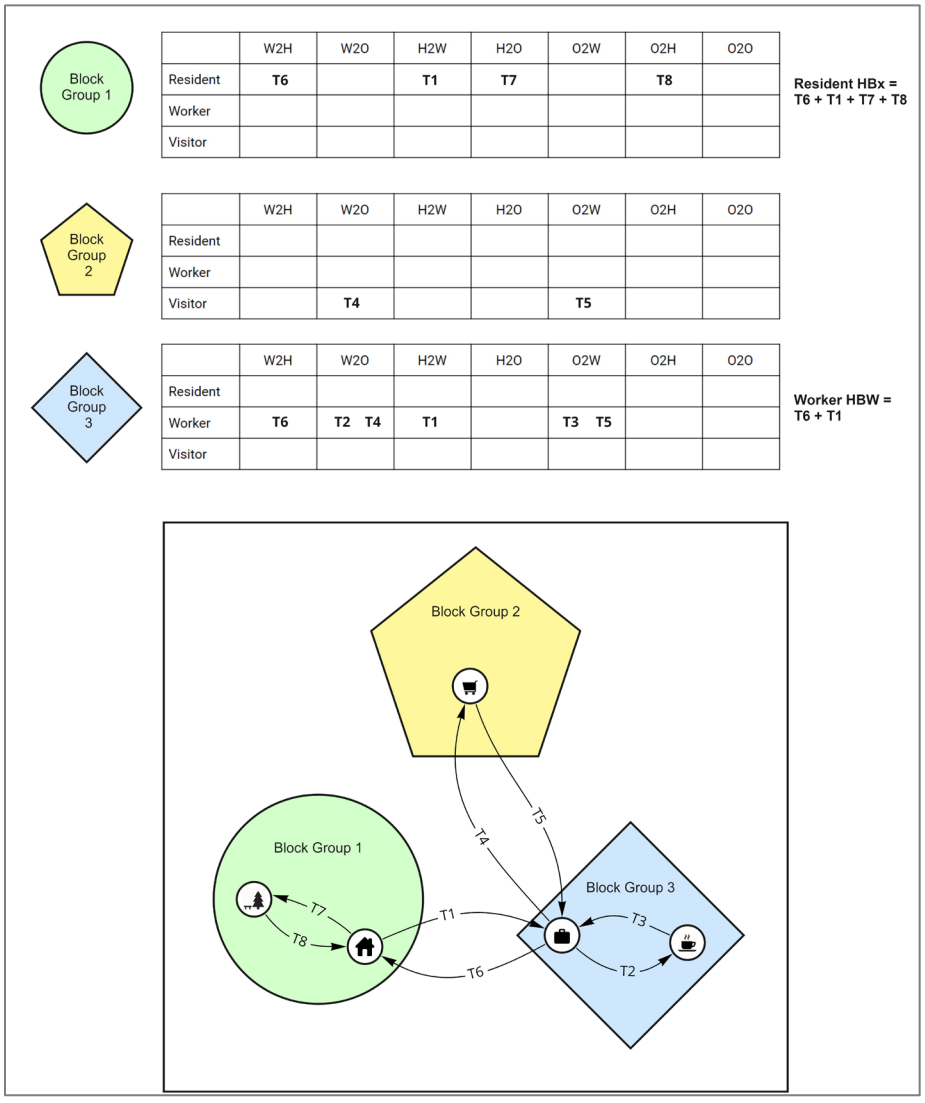


Figure 7: Illustration of how trips are allocated when the device home and work locations are located in different block groups.

We can explore alterations to these definitions on custom implementations and are open to feedback about having additional options for definitions as we move forward with SB 743 support.



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Compact Development Reduces VMT: Evidence and Application for Planners—Comment on "Does Compact Development Make People Drive Less?"

Arthur C. Nelson

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In recent years there have been numerous scholarly articles assessing the relationship between urban form and personal travel (Stevens, 2017/this issue). Most studies show small to modest effects of changes in factors that influence travel behavior considering five D-variables. These articles apply sophisticated statistical analysis to data sets that assess effects of several or all five of the following D-variables on travel:

- *Density*—The number of people, households, or jobs per unit of land area, typically a square mile. Higher densities may reduce trips and trip lengths by making destinations closer together.
- *Diversity*—The mix of land uses in a given area—often square mile, census tract, or transportation analysis zones—with lower values indicating lack of diversity (such as mostly single-family detached homes) and higher values indicating multiple land uses. Diversity can include jobs–people and housing balance usually measured as the ratio of jobs to people (JPH) or households (JHB). Assuming there are 0.6 jobs per person in the region, a JPH of 1.0 means the local area is at balance with the region. Higher measures of diversity are thought to reduce driving and encourage walking and biking.
- *Design*—The extent to which the street network includes a large number of intersections—especially four-way intersections—in the analysis area. This may reduce driving by reducing the network distance route to destinations while also making walking and biking more convenient.
- *Destination accessibility*—The distance from a home to key central locations such as downtown, or the number of jobs accessible by car or by transit within a certain time frame. More accessible destinations may reduce trips or encourage the use of modes other than cars to access them.
- *Distance to transit*—The distance from a home to the nearest transit stop—either all options such as conventional bus and rail or just rail—using the shortest street route. Homes nearer to transit may reduce driving by making transit more convenient.

Statistical analysis applied to the D-variables estimates the extent to which aspects of compact development reduce trips, trip lengths, and per capita vehicle miles traveled (VMT), all things considered. Mark R. Stevens (2017/this issue) asks: "Does compact development make people drive less, and if so, how much less?" (p. 7). He addresses the question by applying meta-regression analysis to 37 studies reported between 1996 and 2015 assessing the relationship between several or sometimes all five D-variables to travel behavior. He finds that compact development does make people drive less, but the impact is fairly small in that "compact development features do not appear to have much influence on driving" (p. 7). He further cautions that "driving is not very sensitive to changes in D-variables. This suggests that compact development has limited potential for making people drive less" (p. 15). In his zeal for caution, Stevens misses an opportunity to show planners how compact development can make a difference in reducing per capita VMT in future plans and development approvals. I do so here. I make my case in the following four sections:

- The Aggregate D-Variable Effects on VMT Are Important;
- The Market Demand for More Compact Development Is Considerable and the Potential for VMT Reduction Is Substantial;
- Application to a Not-So-Hypothetical Example; and
- Summary and Next Steps.

The Aggregate D-Variable Effects on VMT Are Important

Stevens derives elasticities from a meta-regression analysis of 37 studies, which I summarize in Table 1. I report only those elasticities for studies that control for residential self-selection.

Elasticity measures can help planners understand the potential outcome to planning and development decisions. Elasticities estimate the percentage of change in a planning objective—such as reducing per capita VMT—associated with a 1% change in a planning action such as achieving more compact development. While many of the elasticities Stevens reports are quite small, three stand out because they are not: 1) household/population density; 2) job accessibility by auto; and 3) intersection or street density.

Table 1. D-variable elasticities.

D-variable measure	Stevens's corrected elasticities
Distance to downtown	–0.63
Household/population density	–0.22
Job accessibility by auto[a]	–0.20
Intersection/street density[a]	–0.14
Land use mix	0.11
Job density	–0.07
% 4-way intersections[a]	–0.06
Distance to nearest transit stop[a]	–0.05
Job accessibility by transit[a]	0.00
Jobs–housing balance[a]	0.00

Note:
a. Stevens had no need to correct these elasticities to control for self-selection.
Source: Stevens (2017/this issue); adapted from his Table 2, reporting outcomes that control for self-selection.

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For example, from a planning perspective, the elasticity for density can be interpreted as follows:

> Increasing density of households/population by 25% will decrease per capita VMT by 5.5% (0.22 elasticity times 0.25). If density is 2,000 persons or 800 homes per square mile and VMT is 10,000 miles annually per capita, increasing density by 25% to 2,500 persons or 1,000 homes per square mile—just 200 more residential units in a square mile—will reduce annual VMT by 550 miles for each of the 2,500 residents.

This improvement is not trivial. For instance, in this scenario, a doubling of density can reduce VMT by 2,200 miles annually per person, reducing it from 10,000 miles to 7,800 miles per capita for everyone.

Moreover, with caution, elasticities may be combined to create even larger effects. For instance, adding elasticities for household or population density, job accessibility by auto, and intersection or street density results in an elasticity of 0.56. If through good planning and urban design all three of these variables increased by 25% nationally between now and 2050, VMT per capita would fall by 14% (0.56 elasticity times 25% increase) or 1,400 miles, and mean VMT per capita would fall to 8,600 miles. As the United States will add about 100 million people between now and 2050, total VMT will be much larger then than now, but neither would the reduction be trivial.

Applying measures of elasticity can be tricky for two main reasons. The first is that often elasticity estimates are based on small datasets or small ranges between high and low data points. Fortunately, for the purposes of this commentary, nearly 90% of the studies Stevens assesses have more than 1,000 cases, and about one-third include more than 10,000 cases. Because large sample sizes improve the veracity of statistical analysis, this concern seems obviated. Moreover, the ranges used in Stevens's studies are likely quite large. For instance, population, household, and job densities range more than 10 times from the smallest to the largest data point. Intersection densities likely range well over 10-fold from smallest to largest. The distance of homes to downtown, the nearest transit station, and job accessibility by auto or transit can range at least 10-fold and perhaps more than 100-fold (depending on the specific study design).[1] It is unlikely that there are narrow ranges between highest and lowest data points when considering the totality of the studies, so this concern is also obviated. In effect, extrapolating elasticities to estimate effects of a doubling of density, for instance, should not cause much interpretive alarm. This is important for reasons that will be apparent later.

Second, when aggregated, elasticities of two or more variables can over- or underestimate actual effects. Overestimation can occur when the sum of two or more elasticities exceeds the real effect. This happens when they are highly or reasonably highly correlated; the correction could be an index that appropriately weights all variables in the same composite variable. Underestimation can occur when the sum of two or more elasticities is less than the real effect. For instance, in the absence of transit options, the combination of density and transit accessibility elasticities may be less than if there were transit options. Indexing could again be a solution, although with respect to transit, the mode, frequency, quality of stops, and other factors can also affect transit accessibility elasticities. Yet researchers strive to control for these effects to generate estimates with reasonable fidelity, allowing many to be cumulated where appropriate.

By not cumulating appropriate elasticities where reasonable in the context of planning, Stevens's contribution to planning may be understated. From a planning perspective, it may be reasonable to aggregate selected elasticities reported in Table 1 in the manner shown in Table 2. After all, good planning and urban design maximizes benefits by choreographing numerous efforts that individually have small or modest impacts because taken as a whole they can have large impacts. Excluding the variable for distance to downtown, a 1% increase in each of the D-variables listed in Table 2 may be associated with a 0.63% decrease in per capita VMT. One variable stands out for suggesting that an increase in land use mix could

Table 2. Selected D-variables for interpretation.

D-variable	Stevens's corrected elasticity
Household/population density	–0.22
Job accessibility by auto[a]	–0.20
Intersection/street density[a]	–0.14
Land use mix	0.11
Job density	–0.07
% 4-way intersections[a]	–0.06
Distance to nearest transit stop[a]	–0.05
Total	–0.63

Notes: Job accessibility by transit and jobs–housing balance are removed because of their negligible effects based on Stevens's analysis.
a. Stevens had no need to correct these elasticities to control for self-selection.
Source: Adapted from Stevens (2017/this issue).

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increase VMT. While counterintuitive, it could be the case that more land uses close by but without convenient walking, biking, or transit access could induce more traffic between them. Put differently, doubling measures of each variable may have a cumulative effect of reducing per capita VMT by 63%. This is an important contribution to planning for reasons I show next.

The Market Demand for More Compact Development Is Considerable and the Potential for VMT Reduction Is Substantial

Planning for more compact development means increasing household and population density and expanding land use mix and connectivity, thereby improving job accessibility by auto, increasing intersection and street density, and reducing the distance between people and jobs and transit opportunities, among other factors. But these efforts will be successful only if the market wants it to be. Fortunately, this seems to be the case. Consider two indicators: demand for traditionally designed communities[2] and walkable communities.

Based on a survey of more than 10,000 respondents in 2003 and 2005, Handy, Sallis, Weber, Maibach, and Hollander (2008) find that in 2003, more than 40% expressed support for approving or living in a traditionally designed community that included such features as walkable destinations, housing and land use mix, and smaller lots. This support rose to nearly 60% by 2005. Taken together, my interpretation of Handy et al.'s work is that about half of Americans would both support and choose to live in a traditionally designed community. Those communities are typically designed for at least 10,000 persons per square mile and a sizeable employment base, though perhaps not achieving jobs–person or jobs–housing balance (Nelson, 2013). Handy et al. observe that the supply of traditionally designed communities does not meet demand.

More recently, the National Association of Realtors (NAR) and Portland State University (2015) report findings of their survey of 3,000 respondents living in the 50 largest metropolitan areas. As a stated-preference survey, it forces respondents to choose between choices. One of the stated-preference or forced-choice survey questions was this:

> Imagine for a moment that you are moving to another community. These questions are about the kind of community where you would like to live. Please select the community where you would prefer to live.

The choices and responses were:

> (COMMUNITY A) Houses with large yards and you have to drive to the places where you need to go. **45%**
> (COMMUNITY B) Houses with small yards, and it is easy to walk to the places you need to go. **48%**

and

> (COMMUNITY A) Own or rent an apartment or townhouse, and you have an easy walk to shops and restaurants and have a shorter commute to work. **45%**
> (COMMUNITY B) Own or rent a detached, single-family house, and you have to drive to shops and restaurants and have a longer commute to work. **48%**

In the choice among strictly detached residential neighborhood options, slightly more respondents would choose smaller yards (48%) if they could have an easy walk to places compared with those who would prefer larger lots and have to drive places (45%). Designed right, smaller-lot developments with walkable destinations can enjoy many features of compact development, especially if attached housing options are also available (Parolek, 2008).

In choosing between even more stark options, slightly more respondents would choose the "sprawl" option where they need to drive to places and have a longer commute to work (48%) than the compact development option that includes owner- or renter-attached residential options with an easy walk to places and a shorter commute to work (45%). I am impressed with such a small difference in selections between the attached and detached residential options.[3]

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Why is this important? According to the 2013 American Housing Survey (AHS), only 26% of Americans lived in homes where they could walk to places.[4] Put differently, of the roughly 120 million occupied housing units in 2015, the demand for living in walkable neighborhoods—arguably a form of compact development (see Leinberger & Rodriguez, 2016)—is for nearly 60 million homes, but the supply is about 30 million. As the United States adds about 1 million occupied homes annually, even if all homes built between 2015 to the end of the 21st century were in walkable neighborhoods, the demand may still not be met. Perhaps current neighborhoods that are not walkable or compact will become such through infill and redevelopment. If so, we would not need to wait to the end of the century to meet the market demand for these residential options.

Suppose through planning and urban design that by midcentury half of the roughly 160 million homes in the United States then were in more compact communities, an increase of 50 million above my estimate of 30 million in 2015.[5] How would this effect VMT? In 2011, the nation's mean per capita VMT was 9,560 miles (U.S. Department of Transportation, 2011). Despite projected increases, let us assume this does not change by 2050.[6] If 50 million homes comprising roughly 125 million Americans living in areas where the mean of the selected D-variables were double what they are now, through planning and urban design, VMT per capita would be reduced by more than 6,000 miles or about 700 billion total miles. While total VMT would increase considerably, it would do so at a rate substantially lower than current levels. This is not trivial.

What does doubling the selected D-variables mean? In 2010, the urbanized land areas of the United States averaged about 2,500 persons per square mile or roughly the density of the Kansas City (MO) and Orlando (FL) urbanized areas. Double this density would be roughly half the minimum density of modern low-rise new urbanism communities[7] that tend to command a market premium (Song & Knaap, 2003) because a) benefits such as lower VMT are capitalized into higher values and b) demand exceeds supply, among other factors.

But density of development serving new population might nearly double anyway. Consider that in the early 1990s, the average lot size of a new detached home was 0.60 acres but fell steadily to 0.30 acres in the early 2010s.[8] Further, while the total number of detached homes increased about 30%, the number of homes on small lots (less than one-eighth of an acre) doubled to nearly 14 million units. During the same period, attached residential units accounted for about 9 million units of the total change of 27 million units, or one-third. In other words, trends of the past two decades suggest that housing is becoming somewhat more compact, perhaps consistent with emerging market demand. Planning can help accelerate the pace by facilitating more efficient urban forms.

Application to a Not-So-Hypothetical Example

There would seem to be substantial market demand for land use patterns that inherently reduce per capita VMT. Stevens's analysis indicates that per capita VMT can be reduced by choreographing changes to the built environment, perhaps consistent with existing and emerging market conditions. Let us consider the hypothetical example of metropolitan Tucson (AZ). In 2011, its population was 988,000 and is projected to reach 1.5 million by 2050, an increase of about 52%.

Suppose metropolitan area planners consider two scenarios. In the sprawl scenario, 20% of all future development occurs in existing developed areas as infill and redevelopment, and the rest (80%) occurs with roughly the same parameters as existed in 2011. This is roughly how the metropolitan area is trending to grow anyway. The mean distance of a person to downtown increases by 10%, through anticipated transit expansions there will be a 25% decrease in the mean distance to transit, and there will be a 10% increase in household/population density, job accessibility by auto, intersection or street density, land use mix, job density, and four-way intersections. (As the elasticities for the job accessibility to transit and jobs–housing balance variables are zero, they are excluded here.) The analysis summarized in Table 3 shows that between 2011 and 2050, VMT per capita is estimated to fall by 0.75%, the mean VMT per capita falls from 8,627 miles to 8,562 miles, and total VMT increases from 8.5 billion miles in 2011 to 12.8 billion miles, or 51%, roughly comparable with population growth.

In the infill-redevelopment scenario, all (100%) future development occurs in existing developed areas as infill and redevelopment. This is easily imagined given very low development intensities, vast amounts of undeveloped land surrounded by development, and moderately assertive efforts to use public resources to leverage private "smart growth" investment and development. The mean distance of a person to downtown decreases by 20%, anticipated transit expansions will cut the mean distance to transit by half (meaning a 50% reduction in the mean distance to transit), and because new growth is about 50% of existing and occurs within the urbanized area, there will be a 50% increase in household and population density, job accessibility by auto, land use mix, and job density along with a 25%

Table 3. VMT change scenario, metropolitan Tucson (AZ).

D-variable	Baseline and projection	Stevens's corrected elasticity	Tucson Metro sprawl scenario	Tucson Metro @ 20% infill, development	Tucson Metro infill-redevelopment scenario	Tucson Metro @ 100% infill, development
Distance to downtown		–0.63	10% increase[a]	+6.30%	20% decrease	–12.60%
Household/population density		–0.22	10% increase	–2.20%	50% increase	–11.00%
Job accessibility by auto		–0.20	10% increase	–2.00%	50% increase	–10.00%
Intersection/street density		–0.14	10% increase	–1.40%	25% increase	–7.00%
Land use mix		+0.11	10% increase	+1.10%	50% increase	5.50%
Job density		–0.07	10% increase	–0.70%	50% increase	–3.50%
% 4-way intersections		–0.06	10% increase	–0.60%	25% increase	–1.50%
Distance to nearest transit stop		–0.05	25% decrease	–1.25%	50% decrease	–2.50%
Total change				–0.75%		–42.60%
Population 2011	988,000					
VMT 2011, millions	8,524					
VMT per capita, 2011	8,627			8,562		4,952
Projected population, 2050	1,500,000					
VMT reduction, millions				97		3,675
Total VMT, millions				12,844		7,428
Change	52%			51%		–13%

Notes: Job accessibility by transit and jobs–housing balance are removed because of their negligible effects based on Stevens's analysis.
a. Technically an increase in mean distance from downtown means higher VMT.
Source: Elasticities from Stevens (2017/this issue).

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increase in intersection/street density and four-way intersections. Between 2011 and 2050, VMT per capita is estimated to fall by 42.6%, the mean VMT per capita falls from 8,627 miles to 4,952 miles, and total VMT falls from 8.5 billion miles in 2011 to 7.4 billion miles, or 13%. Although metropolitan Tucson grows by 52%, its total VMT in 2050 is actually less than in 2011. The weighted population density (see U.S. Census, 2013) increases from 3,200 to 4,800 persons per square mile, or roughly what metropolitan Denver (CO) was in 2010.

I summarize the limitations and extensions of this application of Stevens's insights next.

Summary and Next Steps

It is possible that planners usually do not know how to apply insights of statistical analysis such as those that Stevens references and synthesizes. My aim is to provide a straightforward way in which to estimate effects in Table 3, and interpret them for planning.

In the hypothetical example, the infill-redevelopment scenario could be considered aspirational yet within reach in the next several decades. It of course represents a best-case scenario assuming that the effect of D-variables on VMT can be maximized. As I allude to earlier, it also assumes that the D-variables are independent and that their individual effects can be summed. The total effect could be smaller, which is perhaps likely, but also larger if there are synergistic effects. This would be the next logical area of research. The point is, VMT reduction would be real and likely substantial.

The benefits to metropolitan Tucson in this example can be considerable. For instance, under the sprawl scenario, the demands of roughly 4 billion more vehicle miles traveled in metropolitan Tucson will need to be met. This is roughly equivalent to 1,500 lane-miles of new roads.[9] At roughly $2 million per land-mile, this comes to about $3 billion. Under the infill-redevelopment scenario, metropolitan Tucson could save $3 billion, which could be used to improve existing roads, enhance pedestrian and bicycle ways, expand transit, and make other strategic investments that improve quality of life.

There are other tangible benefits from reduced VMT per capita. A few of them include reduced greenhouse gases with associated environmental improvements (Ewing,

Bartholomew, Winkelman, Walters, & Chen, 2008), improved physical activity (Ewing, Meakins, Hamidi, & Nelson, 2013), improved public health and traffic safety (Ewing & Hamidi, 2014), and improved economic productivity and resilience (Nelson, 2013). Future work can estimate VMT-related elasticities with respect to these and other benefits so planners can estimate collateral benefits of reducing VMT per capita.

It is past time for the insights of researchers such as those referenced by Stevens and Stevens himself to be made accessible to planners. I trust my commentary helps meet this need.

Acknowledgment

I am indebted to Mark R. Stevens for clarifications of points made in earlier versions of his article, and for application insights.

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Notes

1. I am indebted to Reid Ewing and Shima Hamidi for access to their sprawl index data (Ewing & Hamidi, 2014) to make these points.

2. For a review of traditional neighborhood design features, see National League of Cities (2013).

3. The NAR's 2011 and 2013 national surveys included similar questions. In those, roughly 60% of respondents choosing between the large- or small-lot detached homes options chose the small-lot one, while about 40% of respondents choosing between the attached/walkable or detached/drive-only options chose the attached one. But, when respondents were filtered to include only those living in the 50 largest metropolitan areas, results from the 2013 survey were reasonably comparable with that of the 2015 survey.

4. This is based on my analysis of the American Housing Survey Public Use File for 2013.

5. All new homes would be built in compact, walkable communities, plus about 15 million or one-sixth of all current residential units would become part of a compact and walkable community by midcentury because of infill, redevelopment, and expansion of alternative transportation modes.

6. According to the Office of Highway Policy Information (2016), VMT is actually projected to increase more than 0.5% per year, compounded.

7. See the Congress for the New Urbanism website at https://www.cnu.org/.

8. See the American Housing Survey for the United States for 1991 and 2013.

9. Calculated as [4.2 billion new annual VMT/365 days per year/7,500 VMT per lane-mile based on the local level of service standard].

References

Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., & Chen, D. (2008). *Growing cooler: The evidence on urban development and climate change*. Washington, DC: The Urban Land Institute.

Ewing, R., & Hamidi, S. (2014). *Measuring urban sprawl and validating sprawl measures*. Washington, DC: National Cancer Institute, National Institutes of Health.

Ewing, R., Meakins, G., Hamidi, S., & Nelson, A. C. (2013). Relationship between urban sprawl and physical activity, obesity, and morbidity: Update and refinement. *Health & Place*, *26*(March), 118–126. doi:10.1016/j.healthplace.2013.12.008

Handy, S., Sallis, J., Weber, D., Maibach, E., & Hollander, M. (2008). Is support for traditionally designed communities growing? Evidence from two national surveys. *Journal of the American Planning Association*, *74*(2), 209–221. doi:10.1080/01944360802010418

Leinberger, C., & Rodriguez, M. (2016, June). *Foot traffic ahead: Walkable urbanism in America's largest metros*. Washington, DC: The George Washington University Center for Real Estate & Urban Analysis. Retrieved from http://business.gwu.edu/about-us/research/center-for-real-estate-urban-analysis/research/walkable-urban-places-research/

National Association of Realtors, & Portland State University. (2015). *Community & transportation preferences survey: U.S. metro areas, 2015*. Washington, DC: National Association of Realtors.

National League of Cities. (2013). *Traditional neighborhood development (TND)*. National League of Cities Sustainable Cities Institute. Retrieved from http://www.sustainablecitiesinstitute.org/topics/land-use-and-planning/traditional-neighborhood-development-(tnd)

Nelson, A. C. (2013). *Reshaping metropolitan America*. Washington, DC: Island Press.

Parolek, D. (2008). *Form based codes: A guide for planners, urban designers, municipalities, and developers*. New York, NY: Wiley.

Office of Highway Policy Information. (2016). *FHWA forecasts of vehicle miles traveled (VMT): Spring 2016*. Washington, DC: Federal Highway Administration, U.S. Department of Transportation.

Song, Y., & Knaap, G. (2003). New urbanism and housing values: A disaggregate assessment. *Journal of Urban Economics*, *54*(2), 218–238. doi:10.1016/S0094-1190(03)00059-7

Stevens, M. R. (2017/this issue). Does compact development make people drive less? *Journal of the American Planning Association*, *83*(1), 7–18. doi:10.1080/01944363.2016.1240044

U.S. Census. (2013). *Patterns of metropolitan and micropolitan population change: 2000 to 2010*. Retrieved from http://www.census.gov/population/metro/data/pop_pro.html

U.S. Department of Transportation. (2011). *Table 5–3: Highway vehicle-miles traveled (VMT): 2005, 2010*. Office of the Assistant Secretary for Research and Technology, Bureau of Transportation Statistics: State Transportation Statistics 2011. Retrieved from http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/state_transportation_statistics/state_transportation_statistics_2011/html/table_05_03.html

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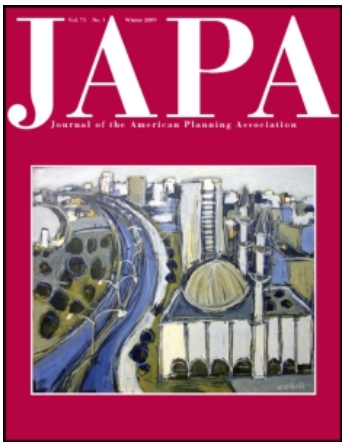
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Arthur C. Nelson

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Preserving Prime Farmland in the Face of Urbanization

Lessons from Oregon

Arthur C. Nelson

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This article combines theory and a literature review with empirical and descriptive findings to demonstrate that Oregon's mix of policies is effective in preserving prime farmland in the face of urbanization. Exclusive farm use zones preserve farmland for farming; urban growth boundaries limit urban sprawl; exurban districts accommodate the demand for rural residential development without harming commercial farm operations; farm tax deferral and right-to-farm laws create incentives for farmers to keep farming; and comprehensive plans legitimize the entire package. This article proposes a comprehensive scheme for farmland preservation that expands on the experience of Oregon, including its mistakes.

Nelson, ASCE, AICP, has been involved in the formation, implementation, and evaluation of farmland preservation policies for twenty years. He is professor of city planning, public policy, and international affairs at Georgia Institute of Technology.

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Only a mix of policies mandated at the state level and implemented by local governments is effective in preserving resource land. Oregon's statewide land use planning program—developed over more than twenty years—exemplifies that mix. This article first reviews the reasons for farmland preservation near urban areas and then the economic impacts of urbanization on farmland. It examines the effectiveness of various farmland preservation policies. The article then describes Oregon's mixed approach to farmland preservation and offers empirical and descriptive evidence of its effectiveness. The article concludes with generalizable lessons for planning policy.

Why Preserve Farmland?

There are three general motivations for preserving prime farmland. First, prime farmland near urban areas is needed for the production of truck and specialty crops (Berry 1978; Sinclair 1967; Zeimetz et al. 1976; Volkman 1987). While some argue that there is no need to preserve farmland near urban areas because there is plenty elsewhere, only about 48 million acres of prime farmland (Soil Capability Class I and II) out of a total of about 250 million acres of cultivated prime farmland (Vining, Plaut, and Bieri 1977) are within fifty miles of the one hundred largest urbanized areas (Furuseth and Pierce 1982). Most prime farmland is located within the suburban and exurban counties of metropolitan areas (Nelson 1990b). Farmland that is most important for its location and productive qualities is also valuable for development (Solomon 1984). Urbanization of prime farmland is presently compensated for by putting lower quality, marginal land into production at greater economic and environmental cost (Platt 1985).

The second purpose of prime farmland preservation is the provision of certain public goods such as flood absorption, air cleansing, and water filtration. The third purpose is open space protection and giving spatial definition to urban areas (Rose 1984). Indeed, it is easy to conclude that the primary motivation behind farmland preservation is open-space preservation.

The Economic Effects of Urbanization on Farmland Value

Some argue that an unregulated land market would result in the most efficient use of land because property owners are best able to determine the appropriate use of their land. This is true only if owners face up to all their marginal social costs. But markets do not operate in an ideal way and so they are imperfect. The purpose of government intervention in the market is to offset many conditions causing inefficiencies (Lee 1979). Interventions can create a complex web that balances public interests with principles of efficiency. But intervention, in the form of economic incentives and disincentives, can sometimes unwittingly cause greater inefficiencies. Examples include underpriced urban facilities and highways

and tax incentives that induce people into buying larger homes on more land than they would without the inducements.

Ironically, land use regulation often aims to correct inefficiencies caused by other public policies.[1] In the absence of market intervention and given the considerable subsidies allocated to urban development relative to those to agricultural production, farmland near urban areas is likely to be overvalued for urban uses and undervalued for agricultural uses. When the land market internalizes those economic advantages into higher values, land is made more valuable for urban uses than would be the case otherwise.[2] This can lead to inefficient speculation of farmland for eventual conversion to urban development.

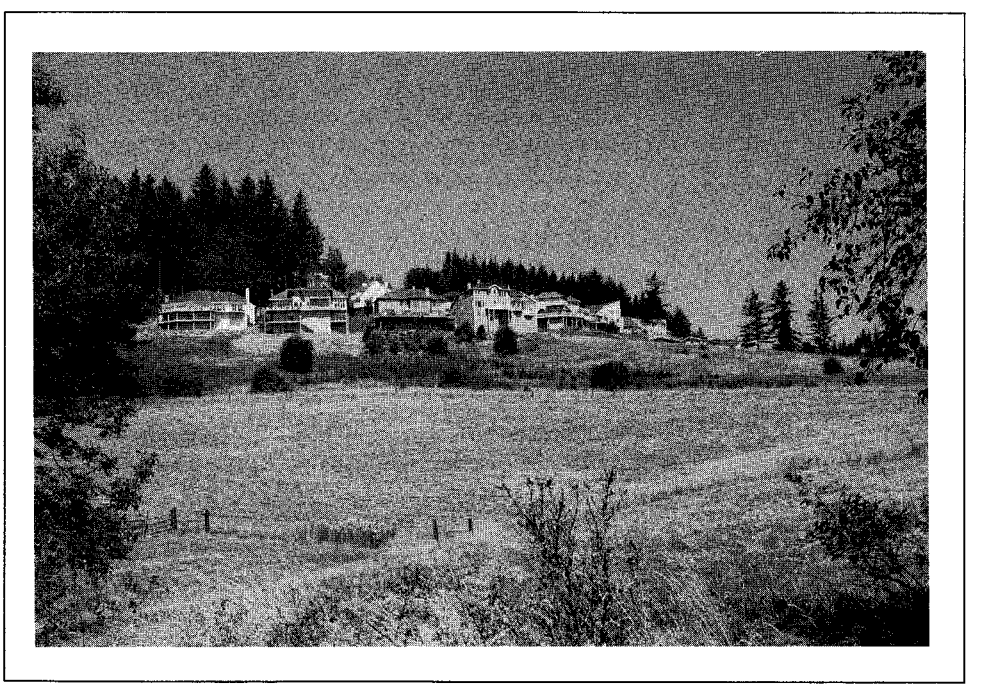
Undervaluation of farmland is also caused when urban development imposes spillovers on nearby farmland. Five common spillover effects are:

- Regulation of farming activities deemed to be nuisances by nonfarm residents in rural areas, including restrictions on fertilizers, manure disposal, smells, and slow-moving farm vehicles on commuter roads; limitations on use of pesticides and herbicides; restrictions on farm noises and hours of operation; restrictions on dust and glare; limitations on irrigation; and restrictions on other activities that may upset the lifestyle of suburban residents (Berry 1978).
- Increased property taxation to pay for schools, roads, services, and facilities intended to serve new residents (Keene et al. 1975).[3]
- Air pollution damage to crops caused by automobiles, industrial activity, and even residential space heating (Prestbo 1975).
- Destruction of crops or equipment or harassment of farm animals by residents of developments in rural areas, and theft of tree crops, berries, and vegetables (Berry, Leonardo, and Bieri 1976).
- Use of eminent domain to acquire at relatively low cost farmland for public uses serving primarily new residential development (Berry and Plaut 1978).

Spillovers reduce the productivity of farmland, thereby making it less valuable for farming and more attractive for speculation. The result of speculation induced by some public policies and by spillovers is that the productive use value of farmland falls the closer it is to urban and other nonfarm development (Sinclair 1967; Boal 1970; Rosser 1978; Nelson 1986a; Meier 1988).

Figure 1 traces several components of farmland value.[4] Raw land value, R_{raw}, is upward sloping to a point to account for the spillover effects that urban development has on farming. The line R_{inv} shows that the higher the investment in land, the more productive farmland is and the more valuable it is for farming. The line is upward sloping with respect to distance from urban development because of spillover effects. The line R_{farm} reflects the total value of farmland. The purpose of farmland preservation policies is to maintain, if not increase, productive value. As the raw value of farmland is fixed with respect to distance from urban development, productive value increases only by investment. Farmland preservation policies are effective only if they result in an increase in farmland investment.

Consumptive value of farmland is sometimes confused with speculative value. Consumptive value, shown as line R_{home}, is the value of farmland if it were "consumed" for nonfarm purposes (Pope 1985). No distinction is made



Urban development is contained by the regional urban growth boundary. The foreground is underutilized farmland within the shadow of urban spillovers.

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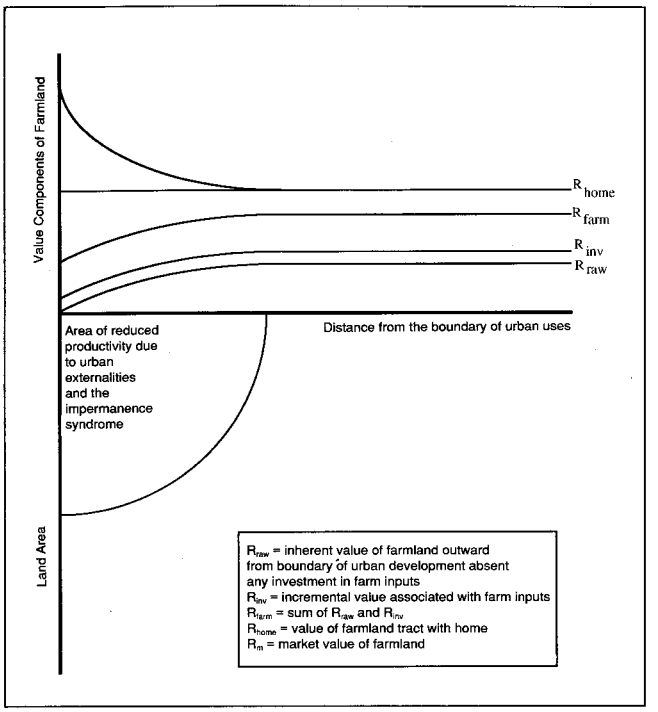


FIGURE 1: Effect of urban development on farmland value.

between the single homesite and subdivision potential values. Every farmland tract with a home has a consumptive value component. Consumptive value is the incremental value of a farmland tract as a single homesite, assuming no further partitioning of the tract can occur.

The difference between R_m and R_{farm} is speculative value. It includes a component called "inefficient speculation," which is the difference between R_m and R_{home}. It arises from distortions created by policies and market imperfections that overvalue land for urban uses and undervalue land for agriculture uses. In the absence of subsidies and urban spillovers, land is more efficiently allocated for farm and urban uses. In Figure 2, the efficient allocation of land occurs where U_1 and R_1 intersect. Land to the left of Q_1 is put to urban uses and land to the right is put to resource uses. The value of land for urban uses increases to U_2, because of subsidies for development, while the value of land for resource uses decreases to R_2 because of urban spillovers. The new equilibrium of land allocation is Q_2. Inefficient allocation of land for urban uses is the difference between Q_1 and Q_2. One aim of planning to preserve farmland in the path of urbanization is to restore the original equilibrium. To be effective, farmland preservation policies must not only eliminate inefficient speculative value, but speculative value that is efficient but for distortions. If speculative value is eliminated, farmland would remain in productive farm use.

There is one more dynamic at work that places farmland in the face of urbanization at a disadvantage. This is the "impermanence syndrome" (Keene et al. 1975; Currier 1978), characterized by the belief among farmers that agriculture in their area has limited or no future and that urbanization will absorb the farm in the not-too-distant future. It is manifested by disinvestment in farming inputs, sale of farmland tracts for hobby farm or acreage development, and shifting of crops from those requiring labor or capital intensity, such as berries and orchards, to those requiring little labor or investment, such as pasture or annual crops. The result can be vast areas of underutilized and idled land near and between urban areas (Gottmann 1961; Berry 1976; Vining, Bieri, and Strauss 1977). It seems that for every acre of prime farmland that is urbanized, up to another acre becomes idled due to the impermanence syndrome (Plaut 1976). When farmers become uncertain about the future viability of agriculture in their area, farmland production falls and so does farming income. Ultimately, the critical mass of farming production needed to sustain the local farming economy collapses (Berry 1976; Daniels and Nelson 1986; Daniels 1986; Lapping and FitzSimmons 1982). The ultimate purpose of a farmland preservation scheme, in the opinion of several researchers, is to remove the impermanence syndrome (Plaut 1976; Berry, Leonardo, Bieri 1976; Berry 1978; NALS 1981; Nelson 1984; 1986a). This occurs only when all speculation for nonfarm purposes is removed.

The Effectiveness of Common Preservation Techniques

Every state has farmland preservation policies. Effective preservation policies, however, must influence the land market in four ways. First, they must increase the productive value of farmland. Second, they must stabilize, reduce, or eliminate consumptive value (value of farmland tracts as a single homesite). Third, they must eliminate inefficient speculative value of farmland, which can happen only if speculative value attributed to urban spillovers, inefficient urban development subsidies, and undervaluation of the public goods provision of resource land, is offset. Fourth, they must eliminate the impermanence syndrome. This is accomplished when the first three objectives are met. Most farmland preservation techniques are ineffective and many have perverse effects. This section reviews why.[5]

Property Tax Relief

When farmland is assessed property taxes to pay for urban services and education mostly benefiting urban residents, farmers bear more than their equitable burden of the tax and they are pushed into developing their land prematurely (Forkenbrock and Fisher 1983). Property tax relief programs reduce the property taxes that farmers would have to pay. To prevent farmers from taking speculative advantage of those programs, most states assess a penalty equal to some of the taxes saved if the farmland tract is developed. No state requires full payback. Many charge no interest or limit the payback period from two

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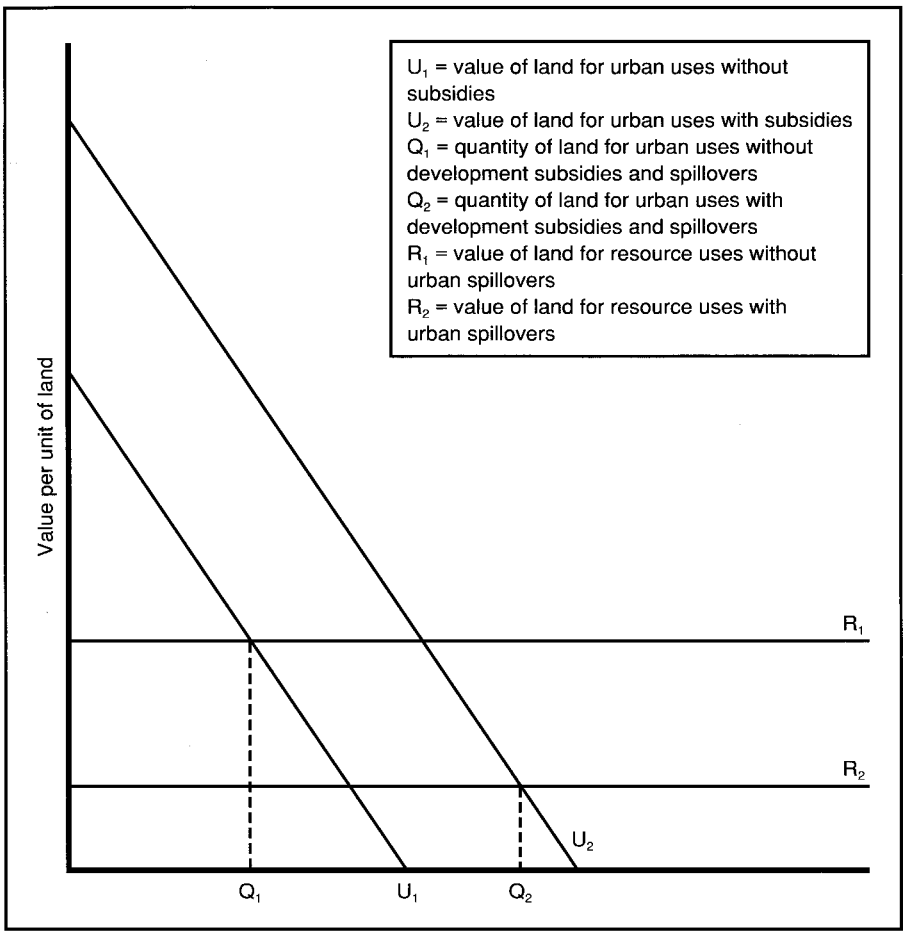


FIGURE 2: Absorption of greater agricultural land area for urban uses because of urban development subsidies and urban spillovers.

to five years. Owners of farmland actually use these programs to speculate, because they never pay 100 percent of the potential payback penalty. These programs have the tendency to induce urban sprawl.[6] In practice, all property tax relief programs create or raise speculative value by distorting land value. All extend the impermanence syndrome farther into the landscape by subsidizing the holding costs of inefficient speculation or turning farmers into speculators.

Right-to-Farm Laws

Suits and the threat of suits can threaten viable commercial farming (Hagman and Juergensmeyer 1987). Right-to-farm laws prevent urban residents from filing nuisance complaints against farmers.[7] All states have right-to-farm laws. At best, they give short-term protection to farmers at the urban-rural fringe. But a farmer could win all the legal battles in court only to lose the proverbial war to expense and wariness. Moreover, the law of trespass has so evolved as to potentially undermine right-to-farm legislation altogether (Leutwiler 1986; Bradbury 1986). The problem is that farmers and urban residents do not coexist. Right-to-farm laws are not likely to be effective in preserving farmland in the long term (Leutwiler 1986; Hagman and Juergensmeyer 1987; Lapping and Leutwiler 1987; Rose 1984; Bradbury 1986; Nelson 1990a).[8]

Acquisition of Development Rights

Some tout transfer of development rights (TDR) and purchase of development rights (PDR) programs as the most effective means of preserving farmland (Rose 1984; NALS 1981; Berry and Plaut 1978). TDR programs, which transfer development to urban areas, preserve farmland at no direct cost to taxpayers. The problem is that the owners of farmland most distant from urban areas are most likely to participate while owners of farmland closest to urban areas anticipate eventual windfalls from development and do not participate. TDR programs do not assure maintenance of the critical mass of farmland needed to sustain the long-term viability of the local farm economy (Lapping and FitzSimmons 1982). Moreover, TDR programs are randomly applied and, thus, do not prevent the scattered subdivision of farmland tracts. Yet, a regional farming economy can be so disrupted by scattered development on land not in PDR programs that it can no longer support the necessary farming infrastructure (Furuseth 1980; 1981; Furuseth and Pierce 1982;

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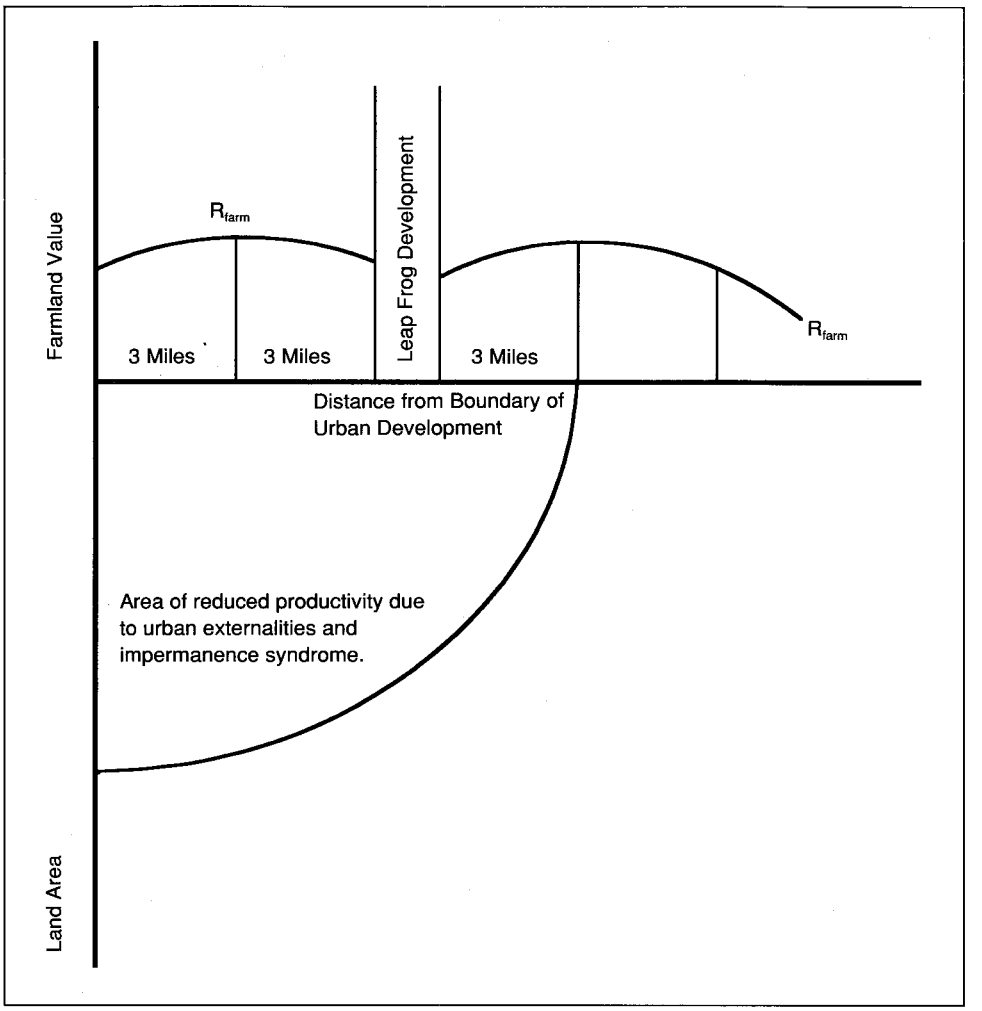


FIGURE 3: Effect of urban sprawl on the productivity of farmland and the impermanence syndrome.

Gustafson, Daniels, and Shirack 1982; Nelson 1983a; 1983b; Daniels and Nelson 1986; Daniels 1986).[9]

PDR programs involve local government purchase of development rights. Taxpayers retire general obligations bonds used to make these purchases to assure the permanent preservation of farmland.[10] Most tracts from which rights are purchased retain single homesite rights or rights in multiples of acres through minimum lot size zoning. Near urban areas, farming districts created by PDR programs can become attractive to affluent households more interested in open space and privacy than in farming (Nelson and Dueker 1989). The preservation of the critical mass of productive farmland is not assured. Moreover, taxpayers pay twice for those rights: once for the infrastructure that creates development value and again for the development value created by infrastructure. Shrewd speculators buy farmland in the path of urban development and then sell development rights at a later time. There are, thus, serious theoretical, practical, equity, and legal problems associated with PDR programs.

At their best, TDR and PDR programs are effective open space measures. At their worst, they are expensive, do not necessarily preserve the local farming economy, and can turn farmland regions into exclusive enclaves of affluent estate holders, while destroying productive farming.

Agricultural Zoning

Agricultural zoning restricts land uses to farming and other kinds of open space activity. It limits subdivision and home construction. It is sometimes used in tandem with regional urban containment planning (Nelson 1985). There are two types of agricultural zoning: nonexclusive and exclusive.

Nonexclusive agricultural zoning restricts lot sizes in agricultural areas from 1 to 160 acres.[11] The higher the density the lower the effectiveness of the minimum lot size approach to preservation. Minimum lot sizing at up to forty-acre densities merely causes rural sprawl—a more insidious form of urban sprawl.[12] However, Napa

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County, California, uses 160-acre minimum lot size zoning, coupled with very strict review of building permits in agricultural areas. Perhaps low-density coupled with development review can be effective. Unless very high minimum lot size restrictions are imposed, however, nonexclusive agricultural zoning does little to prevent the development of farmland in the long term. It also does little to increase productive value, but can lead to increasing consumptive and speculative value by stimulating scattered, low-density urban sprawl into the countryside.

Figure 3 shows the effect of urban sprawl on the productivity of farmland. When development leaps over farmland or occurs along corridors bounded on either side by farmland, vastly more farmland is removed from production. Regional farmland productivity declines and the impermanence syndrome is extended deep into the landscape. In this example, the impermanence syndrome would only extend three miles from the boundary of urban development were it not for leapfrog development (Nelson 1986a). Leapfrog development, however, extends the impermanence syndrome nine miles. Leapfrog and radial development can be stimulated by well-meaning farmland preservation policies that distort speculative and development behavior.

Together with property tax relief, minimum lot size zoning can result in pushing the impermanence syndrome farther into the landscape by forcing urban residents to purchase larger tracts than they want or can manage (Fuller and Mage 1975; Archer 1977; Berry, Leonardo, and Bieri 1976; Nelson 1983a; 1983b; 1986a). Voluntary agricultural districting, which combines some of the elements of tax relief programs and of nonexclusive agricultural zoning, provokes similar effects.

Exclusive farm use zoning prevents nonfarm activities in farming districts. True exclusive farm use zoning requires that farmland be devoted to commercial production. Nonetheless, exclusive farm use zoning can also extend the impermanence syndrome by forcing urban residents to purchase farms larger than they want or can manage. This is countered only when all prime farmland is made subject to exclusive farm use zoning and urban households are funneled away from areas explicitly set aside for nonexclusive farming uses.

The Oregon Approach

Oregon's statewide land use planning program is primarily intended to preserve prime farmland in the Willamette Valley, the state's most heavily urbanized area. The valley stretches one hundred miles north to south and about forty miles east to west. With only 10 percent of the state's land base, one-third of the state's entire supply of prime farmland is found there. It produces about 40 percent of the state's agricultural goods and is home to more than two million of the state's three million people. While Oregon's farmland preservation policies affect the entire state, this evaluation of policy effectiveness primarily focuses on the Willamette Valley.

Instead of relying on one principal technique, Oregon's farmland preservation policies work as a package, which includes exclusive agricultural districts, urban growth boundaries, restrictions on development of exurban districts, and, of lesser importance, farm use tax deferral and right-to-farm provisions. Comprehensive plans legitimize the entire scheme (Daniels and Nelson 1986). The result is a regulated landscape where land is explicitly allocated and restricted to specific uses (Knaap and Nelson 1992). Of the state's 61.6 million acres of land, 55 percent is publicly owned, 2 million acres are contained in urban growth boundaries, and 25.8 million acres are restricted to resource, exception, and other rural uses. Only slightly more than 3 percent of all privately owned land is set aside for hobby farming, ranchettes, or other nonresource uses outside urban growth boundaries, and another 3.3 percent is contained within urban growth boundaries. Table 1 illustrates the distribution of land use designations in Oregon.[13]

Oregon's preservation package centers on statewide planning Goal 3, which conveys Oregon's intent to preserve farmland:

> Agricultural lands shall be preserved and maintained for farm use, consistent with existing and future needs for agricultural products, forest, and open space. These lands shall be inventoried and preserved by exclusive farm use zones. . . . Conversion of rural agricultural land to urbanizable lands shall be based upon consideration of the following factors: (1) environmental, energy, social, and economic consequences; (2) demonstrated need consistent with LCDC [Land Conservation and Development Commission] goals; (3) unavailability of an alternative suitable location for the requested

TABLE 1: Distribution of land use designations in Oregon, 1986

Land use category	Acres[a]	% all land	% privately owned land
Total land area	61,587	100.00	
Publicly owned	33,750	54.80	
Privately owned	27,837	45.20	100.00
Inside UGBs	2,048	3.33	7.36
Outside UGBs	25,789	41.87	92.64
Exclusive farm use	16,036	26.04	57.61
Primary forest use	8,771	14.24	31.51
Rural residential	710	1.15	2.55
Commercial	10	0.02	0.04
Industrial	46	0.07	0.17
Rural service centers	29	0.05	0.10
Other	189	0.31	0.69

a. Figures rounded to nearest 1,000 acres.
Source: Adapted from Department of Land Conservation and Development 1986.

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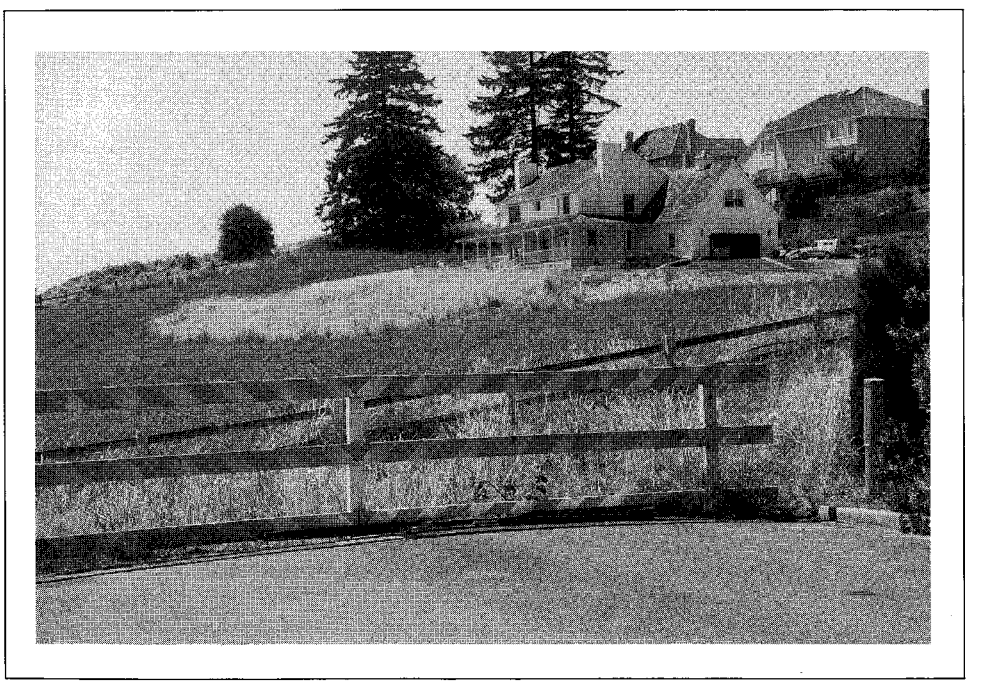
use; (4) compatibility of the proposed use with related agricultural land; and (5) the retention of (Soil Conservation Service–determined) Class I, II, III, and IV soils in farm use. A governing body proposing to convert rural agricultural land to urbanizable land shall follow the procedures and requirements ... for goal exceptions (LCDC 1990, 5).

The policy is administered by the Land Conservation and Development Commission (LCDC), a seven member gubernatorially appointed board and its staff, the Department of Land Conservation and Development (DLCD). All prime agricultural and related land is placed in exclusive farm use (EFU) districts. This land is restricted to farm use unless the impracticability of doing so can be demonstrated in a quasi-judicial proceeding.

Preserving farmland evolved in Oregon from a minimum lot size approach to performance zoning. At first, the LCDC allowed local governments to establish minimum lot size districts to limit parcelization and home construction to large lots. Some eastern Oregon counties created 320-acre minimum lot size districts. Some western Oregon counties attempted five-acre minimums, but most settled on twenty- to forty-acre minimums. This approach, while it prohibited nonfarm uses in theory, did not clearly define acceptable uses. The approach failed largely because many counties attempted to gain the smallest minimums acceptable to LCDC. Owners divided farms and sold the parcels as hobby farms or very large suburban lots. Many critics viewed the minimum lot size restrictions as resulting in worse land use patterns, because they created rural sprawl and the loss of many times more prime farmland than would have resulted from an unrestricted land market (Archer 1977; Nelson 1983a; 1983b; 1990a; Daniels and Nelson 1986). Thus, during the 1980s, the LCDC required counties to create performance-based exclusive farm use (EFU) districts with no minimum lot sizes. Now, the only way to secure a subdivision or home construction approval on such land is to prove in a quasi-judicial setting that the change would improve agricultural production.

In theory, all land outside UGBs is preserved for resource uses. But this is impractical, because some rural land is already built on or committed to nonfarm uses and cannot be converted back to resource use. Other lands simply have soils too poor to sustain reasonable resource practices. Oregon, thus, devised an "exception" category for some rural land.[14]

Oregon's effort to preserve prime farmland is aimed primarily at preventing the occupation of those lands by hobby farmers.[15] "Rural residential areas" are used to attract hobby farmers away from prime farmland. An outgrowth of the exception process, this is an important but often overlooked component of Oregon's farmland preservation program (Gustafson, Daniels, and Shirack 1982).[16] Counties have set aside more than 300,000 acres within the Willamette Valley for rural residential—often called "exurban"—development. Statewide, more than 700,000 acres are set aside for exurban uses. Exurban districts are well suited for hobby farms since their soil is of lower quality and they are situated away from commercial farming areas.



The barricade marks the UGB. Before the boundary was finalized the road was to continue up the hill to a completed subdivision. For two years hobby farmers fought, but lost against a corrected UGB to accommodate subdivision build-out.

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Empirical Evidence of Effectiveness

Is Oregon's approach effective in eliminating speculative use value, limiting consumptive use value, sustaining the critical mass of farmland needed to support the regional agricultural economy, and increasing the productive value of farmland? The regional land market can be evaluated to answer these questions (Nelson 1986a).

Urban growth boundaries, exclusive farm use restrictions, and restricted exurban development policies must effect the outcomes shown on Figure 4. First, the regional demand for land to be used for urban purposes must be shifted from rural land to areas contained within urban growth boundaries to the left of U_1 and to exurban enclaves to the right of U_2. The value of land must shift from R_m to R_p, resulting in an increase in the value of urban and exurban land, but a decrease in the value of farmland. Second, because farmland provides nearby urban and exurban land with scenery, privacy, and other benefits, there is an amenity value increment to urban and exurban land, shown as R_a from U_a to U_1 and from U_d to U_2, respectively. Third, because urban and exurban land impose spillovers, or disamenities, on farmland, resulting in reduced productivity along the urban and exurban boundaries, farmland value falls by the increment R_d from U_1 to U_b and from U_2 to U_c, respectively.

With Portland and Salem, Oregon, as the laboratories, the combination of UGBs and EFU districts indeed shifted the demand for urban land to areas inside UGBs. This resulted in higher urban values and lower farmland values (Knaap 1982; 1985; Nelson 1984; 1985; 1986a; Knaap and Nelson 1988). Exurban land values also shifted upward (Nelson 1984; 1986a; 1986b). These studies show that farmland preservation policies, in combination with urban and exurban containment policies of the sort used in Oregon, are effective in realizing the first objective of farmland preservation: shifting regional demand for urban and exurban development away from prime farmland and into targeted areas.

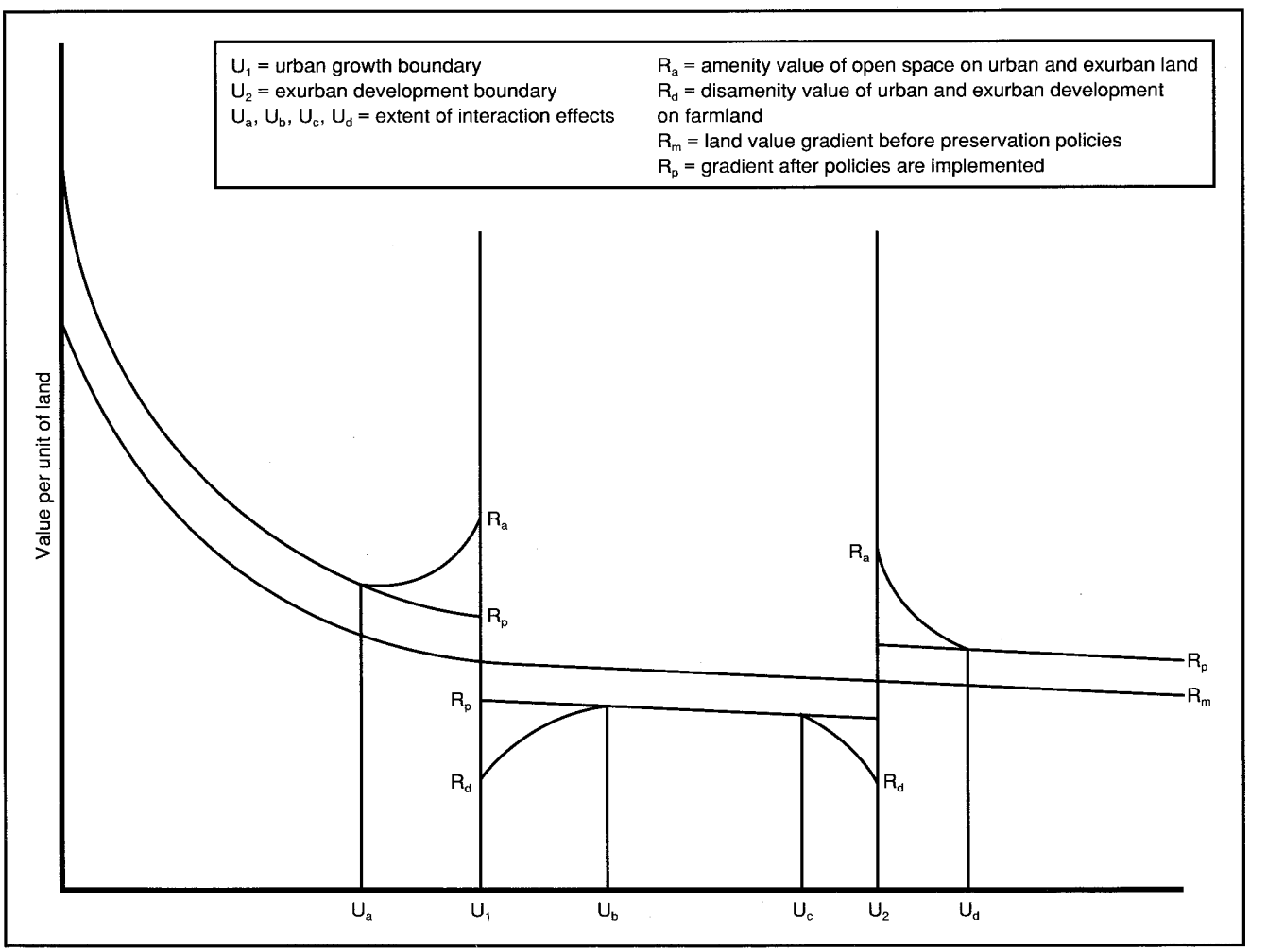


FIGURE 4: Economic objectives of farmland preservation and urban containment policies.

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Second, urban and exurban land proximate to farmland must exclusively internalize quasi-public goods, such as privacy and scenery, into higher values the closer the land is to farmland (Correll, Lillydahl, and Singell 1978). The absence of this effect means that the urban and exurban land markets expect urban development of farmland in the near future. The evaluation of Salem, Oregon, shows that the value of urban land rose with proximity to the Salem UGB where that boundary separated urban development from EFU districts (Nelson 1984; 1986). This phenomenon did not occur where the UGB separated urban development from exurban districts.

The effect should also be found along the boundary separating EFU from exurban districts, as exurban households are like urban or suburban households in their pursuit of space and privacy (Davis 1990; Davis, Nelson, and Dueker 1993; Nelson 1991; Nelson and Dueker 1989; 1990). An evaluation of rural Washington County, Oregon, indicated that the value of exurban land rose with proximity to the EFU boundary (Nelson 1988).

Third, speculation of farmland for nonfarm uses, whether urban or exurban, is eliminated only when the market value of farmland falls as it nears urban and exurban land. This is because non–farmland uses will impose all the negative externalities on nearby farmland. If this effect is not detected, then the market for farmland is internalizing expectations of conversion to urban or exurban nonfarm uses.

The Salem analysis revealed that farmland value fell with proximity to the UGB (Nelson 1984; 1986). This indicates the effectiveness of the exclusive farm use restrictions in eliminating speculative use value from farmland. Farmland value seemed unaffected by urban development only three miles away from the UGB.

An analysis of the interaction between farmland and exurban land in Washington County, Oregon, used the same approach (Nelson 1988). The central question was simple: Does farmland value behave at the exurban boundary as it behaves at the urban growth boundary? The original statistical analysis revealed ambiguous interaction, suggesting no statistically meaningful effects. Perhaps exurban and farmland owners coexist principally because exurban landowners consider themselves quasi-farmers and are therefore sympathetic with commercial farming. Perhaps exurban landowners do not impose spillovers on farmland owners. But this analysis is wrong (Nelson 1990c).

A reevaluation asked at what minimum density does exurban development have no adverse influence on farmland values. Proximity to five- or ten-acre exurban districts resulted in rising farmland value, indicating that the farmland market was internalizing the expectation of conversion to exurban development. This would suggest failure of preservation policies to influence the farmland market in intended ways, resulting in the underproduction of farmland, underinvestment in that land, and emergence of the impermanence syndrome among affected farmland owners. Proximity to twenty-acre exurban districts, however, resulted in declining farmland value, indicating that speculation for conversion to twenty-acre exurban development was not evident.[17] Thus, any exurban density less than twenty acres along the exurban and farmland boundary would have undesirable effects in the farmland market.

Finally, the value of farmland in exclusive farm use districts should rise over time as the farming economy has been preserved and farming investments can be made without concern for the impermanence syndrome. While there is as yet no empirical test of this outcome, the descriptive evidence reported below seems compelling. Production is increasing and this should be associated with increasing farmland value.

Descriptive Evidence of Effectiveness

Based on the 1978 and 1982 Census of Agriculture, Daniels and Nelson (1986) concluded that Oregon's farmland preservation policies were working to preserve large blocks of farmland because of large minimum lot size zoning, but they could not determine whether agricultural production had improved or whether hobby farming and commercial farming coexisted. Instead, they found that Oregon led the nation in the formation of hobby farms between 1978 and 1982, and the future viability of commercial agriculture was in doubt.

A recent study prepared by the LCDC indicates that the preservation of prime farmland improved during the late 1980s (1989). Analysis of the period July 1985 through August 1986 and September 1987 through August 1988 indicates that new and replacement dwellings on EFU lands decreased (see Table 2). The average parcel size of new farm dwelling approvals increased: Two-thirds were on parcels greater than twenty acres in 1987 to 1988 in contrast to one-half in 1986 to 1987. New land divisions within EFU districts increased in size: In 1987 to 1988, 84 percent were larger than twenty acres in contrast to 70 percent in 1986 to 1987. Concern over nonfarm dwellings approved for EFU districts continues. Slightly less than one-half of the nonfarm dwellings were approved for the Willamette Valley and another one-quarter in southwestern Oregon. However, 84 percent of the nonfarm dwellings were approved for parcels of less than ten acres and 70 percent of the land affected was of Soil Class IV or worse. Nonfarm dwelling approvals will become more difficult in future years as the legislature, the LCDC, and special interest groups seek to contain this activity.

Recent data from the United States Department of Agriculture, in its 1987 Census of Agriculture, strongly suggests that Oregon's prime farmland preservation policies seem to work despite the continued proliferation of hobby farms. The conclusion is an important milestone for planning policy everywhere: Urban development and farming can coexist but only when certain land use planning policies are employed and strictly enforced.

TABLE 2: New dwellings on EFU lands, 1985–1988

Type of dwelling	Approved		Denied	
	1987–1988	1985–1986	1987–1988	1985–1986
New farm dwellings	205	230	9	0
Replacement farm dwellings	65	79	1	0
New farm worker dwellings	103	97	8	8
Replacement farm worker dwellings	18	21	1	1
New nonfarm dwellings	279	264	36	17
Replacement nonfarm dwellings	34	60	0	1
Total new dwellings	587	591	53	25
Total replacement dwellings	117	160	2	2

Source: Department of Land Conservation and Development 1989.

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How Does Oregon Compare to the Northwest and the Nation?

Although there are problems with the use of the census, it is the most reliable source of longitudinal data on changes in the farming economy at the county level. The analysis here compares the performance of Oregon's agriculture with that of Washington State and the United States between 1982 and 1987. Washington State is a reasonable control, because it does not have Oregon's statewide farmland preservation mandate, but is otherwise similar (Daniels and Nelson 1986). Comparison with the U.S. can indicate strengths and weaknesses of the Oregon farming economy relative to national trends. The analysis also evaluates changes in farming performance among the nine Willamette Valley counties. The farmland policies of Oregon are not conclusively related to changes in performance relative to other states, the nation, or periods of time. The evidence presented is only circumstantial, but reasonably compelling.

Between 1982 and 1987, the entire nation lost more than 50,000 farms (see Tables 3 to 5). Oregon lost more one- to nine-acre farms proportionally than Washington or the U.S., but generally lost fewer farms proportionally above ten acres. It actually gained in the number of farms of more than five hundred acres, whereas Washington lost farms in this category. Overall, Oregon lost more smaller farms but gained more larger farms than Washington or the U.S. This is limited evidence that the preservation policies discouraged proliferation of smaller farms and preserved, if not expanded, larger farms. Unfortunately, census data do not allow analysis of what happened to those smaller farms. They may have been taken entirely out of the farmland pool (which may be undesirable) or merged to make larger units (which may be desirable).

During the same period, the nation added almost 18,000 farms reporting more than $10,000 in earnings. They can be considered *commercial* farms (Daniels 1986).[18] Oregon gained proportionately more commercial farms of 1 to 49 acres than Washington or the U.S., lost proportionately fewer commercial farms of 50 to 499 acres than the nation, and gained proportionately more

TABLE 3: Changes 1982–1987 in distribution of farms by size and total farm acreage

	Oregon			Washington			United States[a]		
	1982	1987	% change	1982	1987	% change	1982	1987	% change
Number of farms									
1–9 acres	5,987	5,476	−8.54	6,425	6,040	−5.99	181,712	177,781	−2.16
10–49 acres	12,415	11,448	−7.79	12,717	11,362	−10.66	436,886	400,989	−8.22
50–179 acres	7,662	7,219	−5.78	7,755	7,216	−6.95	704,039	637,630	−9.43
180–499 acres	3,906	3,617	−7.40	4,035	3,796	−5.92	522,660	474,677	−9.18
500 or more acres	4,117	4,254	3.33	5,155	5,145	−0.19	361,740	364,668	0.81
Total, all sizes	34,087	32,014	−6.08	36,087	33,559	−7.01	2,207,037	2,055,745	−6.85
Acreage (thousands) in farm use									
Total, all farms	17,740	17,809	0.39	16,470	16,116	−2.15	996,724	946,662	−5.02

a. Figures adjusted to exclude Oregon for comparability purposes.
Source: U.S. Department of Agriculture, *1987 Census of Agriculture.*

TABLE 4: Number of commercial farms and acreage in commercial farms, 1982–1987

	Oregon			Washington			United States[a]		
	1982	1987	% change	1982	1987	% change	1982	1987	% change
Number of commercial farms[b]									
1–9 acres	476	634	33.19	864	994	15.05	40,128	44,008	9.67
10–49 acres	1,767	1,891	7.02	3,100	3,072	−0.90	75,528	71,574	−5.24
50–179 acres	3,156	3,010	−4.63	3,832	3,697	−3.52	284,171	241,058	−15.17
180–499 acres	2,706	2,479	−8.39	2,982	2,760	−7.44	398,585	353,971	−11.19
500 or more acres	3,658	3,694	0.98	4,843	4,764	−1.63	334,083	340,948	2.05
Total, commercial farms	11,763	11,708	−0.47	15,621	15,287	−2.14	1,132,495	1,051,559	−7.15
Acreage (thousands) in farm use									
Total, commercial farms	15,488	15,441	−0.30	13,017	13,766	5.75	795,792	813,580	2.24

a. Figures adjusted to exclude Oregon for comparability purposes.
b. Farms reporting $10,000 or more in annual sales, not adjusted for current dollars.
Source: U.S. Department of Agriculture, *1987 Census of Agriculture.*

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commercial farms of more than 500 acres than Washington. Overall, Oregon lost some commercial farm acres while Washington and the nation gained. On the other hand, the proportion of commercial farms to all farms rose faster in Oregon than in Washington, but fell across the nation.

What accounts for the considerable discrepancy in the proportion of small commercial farms in Oregon relative to Washington and the nation? Reduction of commercial farms of 180 to 499 acres may be partly explained by the rise in small farms. Farmland preservation has possibly induced an increase in commercially active hobby farms in Oregon, because settlement on small farms requires demonstration of commercial production. Has Oregon's farmland preservation program led to the division of large farms into smaller ones, or resulted in declining overall farmland production? The answer to this is based on an evaluation of the Willamette Valley, where hobby farm and land subdivision pressures are the greatest.

Performance in the Willamette Valley

Tables 6 and 7 report performance in the Willamette Valley.[19] The number of farms in the Willamette Valley fell by more than one thousand from 1982 to 1987, while the amount of farmland acreage remained nearly the same, falling by slightly more than 1 percent. The virtually unchanged farm acreage figure suggests that the farmland base stabilized over this period. Considering that in 1973 the valley lost 30,000 acres of farmland to urban uses, it would appear that farmland preservation policies caused stabilization since 1978.

Note that the number of commercial farms in the valley rose by nearly 18 percent and the farm acreage in commercial farms rose by 11 percent, or nearly 130,000 acres. The largest share of commercial farm increases occurred in the one- to nine-acre category, while the largest farm acreage gain occurred in the more than five hundred acre category. The proportion of commercial farms to all

TABLE 5: Ratio of commercial farms to all farms, 1982–1987

	Oregon			Washington			United States[a]		
	1982	1987	% change	1982	1987	% change	1982	1987	% change
1–49 acres	0.122	0.149	22.40	0.207	0.234	12.83	0.187	0.200	6.81
1–9 acres	0.080	0.116	45.62	0.134	0.165	22.38	0.221	0.248	12.09
10–49 acres	0.142	0.165	16.06	0.244	0.270	10.91	0.173	0.178	3.25
50 or more acres	0.607	0.609	0.26	0.688	0.694	0.95	0.640	0.634	−1.01
50–179 acres	0.412	0.417	1.23	0.494	0.512	3.68	0.404	0.378	−6.34
180–499 acres	0.693	0.685	−1.07	0.739	0.727	−1.62	0.763	0.746	−2.22
500 or more acres	0.889	0.868	−2.27	0.939	0.926	−1.44	0.924	0.935	1.24
All sizes	0.345	0.366	5.98	0.433	0.456	5.23	0.513	0.512	−0.31

a. Figures adjusted to exclude Oregon for comparability purposes.
Note: Commercial farms include those reporting $10,000 or more in annual sales, not adjusted for current dollars.
Source: U.S. Department of Agriculture, *1987 Census of Agriculture.*

TABLE 6: Willamette Valley, 1982–1987, distribution of farms by farm size; farm acreage by farm size; and commercial farms by farm size

	Number and percentage change		
	1982	1987	% change
Distribution of all farms by farm size			
1–49 acres	10,986	9,900	−9.89
1–9 acres	3,721	3,256	−12.50
10–49 acres	7,265	6,644	−8.55
50–499 acres	5,076	4,674	−7.92
50–179 acres	3,579	3,301	−7.77
180–499 acres	1,497	1,373	−8.28
500 or more acres	764	791	3.53
All farms	16,826	15,365	−8.68
Distribution of farm acreage by farm size			
1–49 acres	189,129	174,745	−7.61
1–9 acres	18,913	16,315	−13.74
10–49 acres	170,216	158,430	−6.92
50–499 acres	770,047	714,556	−7.21
50–179 acres	330,066	309,182	−6.33
180–499 acres	439,981	405,374	−7.87
500 or more acres	820,547	868,490	5.84
All farms	1,779,723	1,757,791	−1.23
Distribution of commercial farms[a] by farm size			
1–49 acres	1,157	1,490	28.78
1–9 acres	242	391	61.57
10–49 acres	915	1,099	20.11
50–499 acres	2,133	2,248	5.39
50–179 acres	1,323	1,233	−6.80
180–499 acres	810	1,015	25.31
500 or more acres	644	900	39.75
Total, all farms	3,934	4,638	17.90
Total commercial farm acreage	1,196,618	1,326,453	10.85

a. Farms reporting $10,000 or more in annual sales, not adjusted for current dollars.
Source: U.S. Department of Agriculture, *1987 Census of Agriculture.*

farms rose substantially in all major farm size categories during this period.

There has been a general reduction in smaller farms but an increase in commercial farms in all farm size categories. Farmland owners are either taking their land out of production— thereby accounting for reductions in all but the largest of the farm size categories for all farms— or they are making their land commercially productive by merging it with other land through sale, rental, or other agreement. Overall, commercial farm production rose to $909 million in 1987 from $619 million in 1982, or nearly 50 percent. Per farm income among commercial farms rose from $157,000 in 1982 to $196,000 in 1987, or nearly 25 percent. These increases exceed the inflation rate during the period.

Table 8 compares Oregon to Washington and the nation. Oregon lost farms on a pace with the nation and Washington. It gained land in farms, however, while Washington and the nation lost land. Average farm size increased more in Oregon than in Washington and the nation. Oregon lost proportionately slightly more cultivated and irrigated farmland than Washington and the nation. Its average value per farm and per acre fell slightly more relative to Washington and the nation. Yet, its sales of farm products per farm rose at nearly twice the rates of Washington and the nation.

Earlier studies revealed no substantial differences in farming performance between Oregon and Washington, and with most national trends, between 1978 and 1982 (Daniels and Nelson 1986). Evidence now suggests the budding of divergent trends. The Willamette Valley farming economy appears more robust after full implementation of farmland preservation policies. Hobby farms and commercial farms in Oregon, especially in the Willamette Valley, are gaining in economic vitality. There has been some concern that the rise of hobby farms could result in reduced commercial farming productivity. Yet, in the valley, while the total number of smaller farms fell, the rise in productivity of commercial hobby farms (one to forty-nine acres) parallels the rise in productivity of commercial farms. This suggests that in Oregon's regulatory environment, both commercially minded hobby farmers and large-scale farmers not only coexist but mutually benefit. They may add dimensions to the farming economy and infrastructure that are mutually reinforcing. The formation of hobby farms has slowed, and some farms appear to have consolidated. Many hobby farmers have become viable commercial farming operators in their own right. It seems likely that were it not for hobby farmers and their sustenance of the economic infrastructure, the large-scale commercial farming operations might be jeopardized. Firm confirmation of this symbiotic relationship remains an open question. Also mutual coex-

TABLE 7: Willamette Valley, 1982–1987, ratio of commercial farms and acreage to all farms and acreage

	Number and percentage change		
	1982 ratio	1987 ratio	% change
Ratio of commercial[a] farms to all farms			
1–49 acres	0.105	0.151	42.91
1–9 acres	0.065	0.120	84.64
10–49 acres	0.126	0.165	31.34
50–499 acres	0.420	0.481	14.46
50–179 acres	0.370	0.374	1.05
180–499 acres	0.541	0.739	36.63
500 or more acres	0.843	1.138	34.98
Total, all farms	0.234	0.302	29.11
Ratio of total acres in commercial farms to total acres in all farms			
Total commercial farm acreage	0.672	0.755	12.35

a. Farms reporting $10,000 or more in annual sales, not adjusted for current dollars.
Source: U.S. Department of Agriculture, *1987 Census of Agriculture.*

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TABLE 8: Farming vitality indicators, 1982-1987, Oregon, Washington, and United States

		Oregon			Washington			United States[a]		
Indicator	Unit	1982	1987	% change	1982	1987	% change	1982	1987	% change
All farms	Number	34,087	32,014	−6.08	36,087	33,559	−7.01	2,207,037	2,055,745	−6.85
Land in farms	Acres, k	17,740	17,809	0.39	16,470	16,116	−2.15	996,724	946,662	−5.02
Average farm size	Acres	520.43	556.29	6.89	456.40	480.23	5.22	451.61	460.50	1.97
Harvested cropland	Acres, k	3,306	2,833	−14.31	5,279	4,597	−12.92	326,306	282,224	−13.51
Irrigated farmland	Acres, k	1,808	1,648	−8.85	1,638	1,519	−7.26	49,002	46,386	−5.34
Nominal value/farm	Dollars	$371,644	$299,755	−19.34	$423,352	$355,976	−15.91	$345,869	$289,387	−16.33
Nominal value/acre	Dollars	$705	$542	−23.12	$933	$739	−20.79	$784	$627	−20.03
Value, sales/farm	Dollars	$48,129	$57,664	19.81	$78,469	$87,000	10.87	$58,858	$65,165	10.72

a. Figures adjusted to exclude Oregon for comparability purposes.
Source: U.S. Department of Agriculture, *1987 Census of Agriculture.*

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istence may not work outside Oregon. One of the underpinnings of Oregon policy is that farmland buyers must engage the land in farming, and many exurban districts have land use and development restrictions that aim to minimize potentially adverse interactions between exurban residents and farmers.

Weaknesses in Implementation

Effectiveness is always dictated by implementation. Daniels and Nelson (1986) recount how local government actions through the mid-1980s undermined state resource land preservation policies. Although recent analyses by the LCDC (1989) and the *1987 Census of Agriculture* show improvement in local government implementation, there is room for more rigor. For example, in an analysis of parcelization and dwelling unit approvals in prime agriculture and forest areas, Pacific Meridian Resources (1991) found some evidence of potentially lax enforcement of preservation policies:

- The majority of new dwellings approved in EFU areas were not being used in conjunction with commercial farm use, defined as $10,000 annual income from farming.
- Most farm operations of less than 80 acres on which new dwellings were permitted reported no farming receipts; about 90 percent of farm operations of less than 160 acres reported no farming receipts.
- More than one-half (358) of farm operations approved for new dwelling units statewide (667) were found in the Willamette Valley.
- About one-third of the forest operations that received approval for new dwellings units are not being managed for timber production.

In part because of this analysis, LCDC amended the agricultural and forest land goals in late 1992. By the late 1990s, local plans will identify and regulate "high-value" and "important" farmlands and "small-scale resource lands." High-value farmlands are suitable for commercial scale operations. Small-scale resource lands are suitable for noncommercial scale agriculture and forest operations. Important farmlands are all other rural lands, other than exception lands, suitable for some level of agricultural production. The purpose of the amendments is to put more pressure on local governments to preserve prime (high-value) farmland. Hobby farm activities would be steered into small-scale resource lands and, to a lesser extent, into important farmlands.

Toward Effective Farmland Preservation Policies

Perhaps the most important lesson from Oregon's experience is that successful farmland preservation relies on a package of techniques that reinforce each other. EFU districts preserve farmland for farming in the long run; UGBs prevent urban sprawl; exurban districts accommodate the demand for rural residential lifestyles without harming commercial farm operations; farm tax deferral and right-to-farm laws create incentives for farmers to keep farming, and comprehensive plans legitimize the entire package. This concluding section offers a regional landscape planning scheme that incorporates the best of Oregon's experiences while improving on its shortcomings.

Urban Containment

The argument that urban development ought to be contained within urban growth boundaries, urban service limits, urban stoplines, or other regulatory fixtures on the regional landscape map has been extensively and persuasively made.[20] Urban containment planning begins with estimates of future land use needs by general land use categories. Status quo trends are not simply projected into the future. The whole idea behind containment planning is achieving more efficient use of urban land: more housing units per acre, higher single-family detached dwelling densities, more flexible site planning standards allowing zero lot line and cluster opportunities, more mixed use projects and comprehensively planned communities, and higher density work environments. The

planning horizon may be set at twenty years but the UGB may have a much longer life as redevelopment and in-fill to higher densities occurs after twenty years. Such planning, however, should also include an *ultimate* UGB that establishes for perpetuity the final extent of urban development within a region.

Figure 5 illustrates the regional landscape scheme. Within the ultimate UGB there are three classes of land, each catering to a particular generation of development—the urban and urbanizable, the future urbanizable, and the urban reserve. The intermediate boundary at U_1 marks the area to accommodate immediate urban development needs. Point U_2 marks the near-term urban growth boundary, and U_3 is the ultimate growth boundary. The future urbanizable land would be expected to be developed within twenty years. The urban reserve land would accommodate very low-density uses until redeveloped to higher densities after twenty years.

Future urbanizable land would not be developed until land inside the intermediate boundary was suitably developed. This concept has been used in the urban areas of Portland, Salem, and Eugene. Minimum lot size zoning of at least ten acres would apply to the future urbanizable land to keep it in such sizes and shapes as to accommodate efficient future development.[21] Long-term facility and transportation plans would explicitly include this land. As all future urbanizable land is developed, within twenty years or so, expansion into the urban reserve lands toward the ultimate UGB would occur only if in-fill and redevelopment options failed.

The urban reserve area would contain land that Oregon now places outside the UGBs in "exception" areas. If Oregon has made any mistake in its planning it is in making its UGBs too small and in preventing adjacent or nearby exception lands from being placed within them. The LCDC required all urban areas to include within their UGBs just the amount of land needed to accommodate the urban development needs to the year 2000.[22] Many UGBs are virtually encircled by these exception lands, which are not needed for urban development and are not suitable for resource or open space activities.

These exception lands should have been included inside the UGBs to better manage their development and to improve long-term management of urban development. Under the present arrangement, because exception lands are neither urban nor resource lands, they are routinely developed for large acreage housing subdivisions, churches, convenience stores or centers, and other patently urban uses. Even though many exception lands adjacent to UGBs are subject to five-acre minimum lot size development, there is concern that it is actually easier to develop them than urban lands (Nelson 1992).

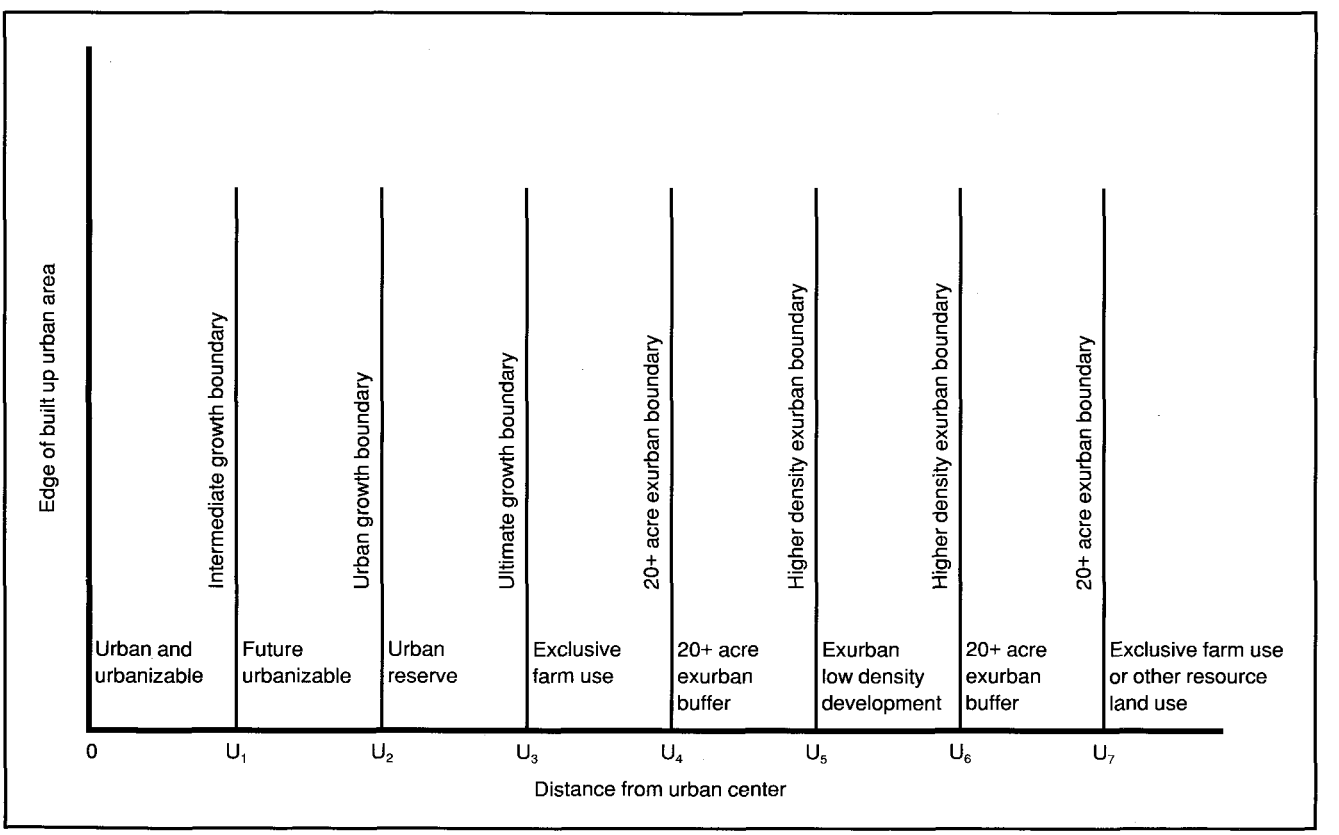


FIGURE 5: Regional planning scheme to preserve farmland.

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Portland's Buddhist community could not receive a conditional use permit to build their temple in the city. Instead, they built it outside the UGB on prime farmland, as EFU zoning in Oregon allows churches as conditional uses.

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What will happen when urban development under Oregon's scheme hits the twenty-year UGB? The assumption is that urban development will be accommodated through in-fill and redevelopment. But this may not take care of all needs. In some situations, the UGB must be expanded. One logical place for expansion would be the exception areas already abutting UGBs. However, by the time UGB expansion into those areas becomes necessary, they will have been developed and occupied by affluent households capable of mounting serious opposition. This is already happening (Nelson 1990b). Is UGB expansion the NIMBY of the future?[23]

A corollary mistake was that Oregon ignored the demand for hobby farms and exurban development (Nelson 1983a; 1983b; Daniels and Nelson 1986). While prospective hobby farmers or pursuers of rural living require only one to two acres, most exception areas are limited to five-, ten-, and twenty-acre minimum lot sizes. As those seeking small tracts are forced into buying larger tracts, more, not less, land is absorbed to accommodate this demand. It would have been far better for the LCDC to have allowed for the accommodation of the demand for small, one- to two-acre tracts within prescribed areas. Those areas should have been within UGBs to the maximum extent possible, and actual development of those sites should be subject to site planning restrictions requiring large setbacks—one hundred feet or more—from nearby resource lands, placement of homes to enable efficient resubdivision into single-family detached sites at some time far into the future, and prohibitions against covenants and deed restrictions that prevent future land assembly or resubdivision. Much of the legitimate demand for five- to ten-acre tracts should be accommodated in the same way.

Exurban Land Outside Urban Growth Boundaries

Even if much of the exception land could be placed inside UGBs there would remain pockets of exception land, classified as antiquated rural subdivisions, five- to ten-acre hobby farms, and twenty acre or more buffer areas.

Antiquated rural subdivisions were approved prior to modern planning review. Many are already developed or committed to residential uses, but these areas can be better managed to preserve the integrity of nearby resource lands. For example, site planning restrictions should require home construction at least one hundred feet away from nearby or abutting resource lands. Owners of those sites should waive remonstrances against resource land use practices as a condition of receiving a building permit. In cases where antiquated subdivision plats are largely undeveloped but nonetheless committed, planning review should result in identifying those portions of the plat that may be reasonably used for resource or buffer activities (Nelson and Recht 1988).

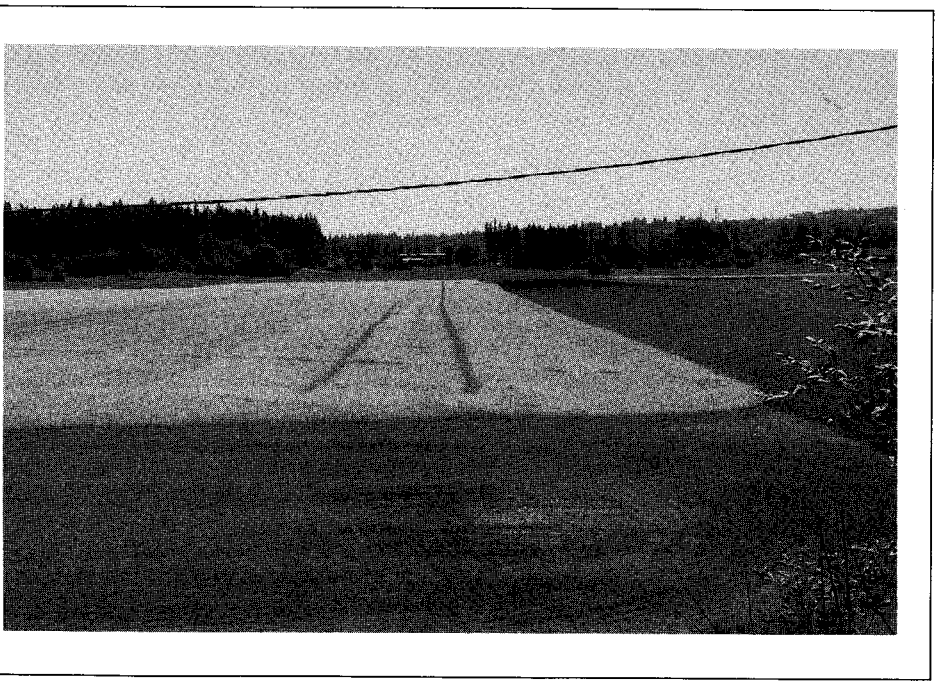
Small-acre hobby farms on exception land outside the UGB should not abut EFU districts to avoid the expectation of conversion to exurban development. The exception lands abutting EFU districts should be subject to higher minimum lot sizes, of at least twenty acres. Development restrictions should be imposed to have those lands used for legitimate resource purposes as a condition of receiving building permits. In the case of forest land, the state forester could review and approve a small woodlot plan set aside by the homebuilder, where forest uses are proposed. The local county assessor could attest to the property being eligible for farm and forest use tax deferral. With these assurances the building permit could



Only a small strip of land is mowed around this hobby farm in an exception area bounded by EFU restrictions. The unmowed areas contain plants toxic to livestock.

be issued. Failure to carry out the pledge would result in zoning violations. Only in rare cases where land is clearly unusable for resource activities, such as developed or committed antiquated plots, would these requirements not apply. In all cases, home construction would also be subject to site plan review, which would require the maximum possible distance from farmland or other primary resource lands.

Where possible, twenty plus acre exurban districts would be placed between EFU and other primary resource land, and higher density exurban land or the UGB. At twenty and more acres, land can be used for a variety of resource activities, which would be required as a condition of building approval. By placing twenty plus acre tracts next to and near farmland and other primary resource districts, operators on those districts can more



A large farm adjacent to an exception area operates only two miles from the UGB. Onions are the dominant crop in this area.

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easily rent the tracts for a variety of resource uses. Moreover, owners of these buffer tracts are more likely than owners of higher density exurban land to consider themselves like farmers and should be more tolerant of farming, forestry, and other resource practices.

Summary Scheme: Toward Regional Urban Form

The planning scheme divides the regional landscape beyond the ultimate urban growth boundary into twenty plus acre minimum lot size exurban districts buffering EFU lands from small acreage exurban districts. Regardless of regional urban development pressures, the ultimate UGB would remain fixed to preserve farmland and other resource lands. The twenty plus acre exurban buffer districts would also remain fixed, although low-density urban-type development could possibly invade selected exurban districts. The ideal regional urban form is achieved through regional landscape planning that includes the creation and rigid enforcement of development boundaries supplemented by rigidly enforced land use restrictions on exurban and resource land.

Figure 6, which combines elements of Figures 4 and 5, shows what the regional economic landscape must look like. If these relationships are not observed, farmland preservation policies may not be effective and perverse outcomes may be at work. Failure may be caused by uniquely local circumstances that require refinement of the scheme. Failure may also be attributable to lax enforcement in issuing development approvals.

First, the regional landscape planning scheme must affect the regional land market in predictable ways. The regional demand for urban land must be shifted from the regional landscape to areas inside the UGB. Actually, the near-term regional demand should be entirely shifted to the area within the intermediate growth boundary and the long-term demand should be shifted to the area between the intermediate and the twenty-year UGB. The regional demand for exurban land uses should be shifted principally from all rural land to areas either between the twenty-year and ultimate UGBs or within exurban districts located outside UGBs.

Second, there should be no interaction of land value along the intermediate growth boundary. Owners of urban land just inside and owners just outside the intermediate boundary should expect the boundary to be moved outward and urban development to occur in the new space in the near future. Similarly, there should be no interaction effect between land just inside and outside the twenty-year UGB.

Along the ultimate UGB there should be interaction effects. Land just inside the ultimate UGB should rise in value the closer it is to the UGB, because it should capitalize the quasi-public goods or benefits that it exclusively enjoys. Just outside the ultimate UGB, farmland or other resource land value should fall the closer it gets

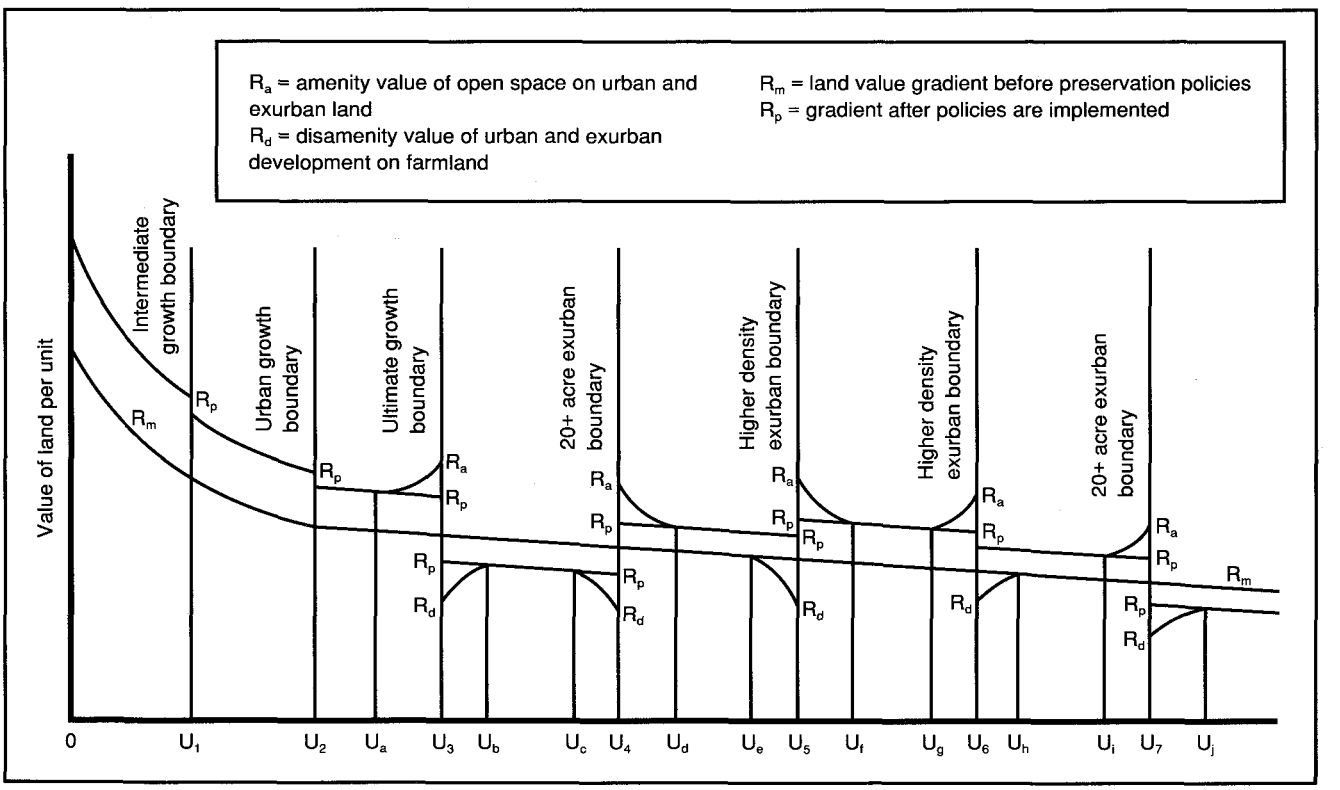


FIGURE 6: Regional economic landscape that preserves farmland in the face of urbanization.

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to the UGB, because urban spillover effects dampen productivity and therefore reduce the value of this land for resource production. It is possible that these effects would not be detected until exurban or urban development came to the UGB.

Along the boundary separating farmland and the exurban twenty acre plus buffer districts there should be similar effects. Through site development review home and work structures could be so removed from the boundary that they would not necessarily impose spillovers on farmers. If home construction in this district required putting land into resource activities and waiving remonstrances against farming activities, spillovers could be prevented. Farmers could lease these tracts for farm use. Avoiding the internalization of spillovers is a desirable outcome that is limited to twenty plus acre exurban buffer districts. In any event, the value of the exurban buffer land would rise the closer it gets to farmland, because it will exclusively enjoy the quasi-public goods and benefits of farmland proximity. However, public policy must be firm in maintaining the integrity of the exurban buffer district to avoid undesirable interactions between owners of those tracts and farmers.

Along the boundary separating the exurban twenty plus acre buffer districts from higher density exurban districts, the interactions are much more fluid and problematic, even ambiguous. If public policy is firm in maintaining the integrity of the twenty acre plus buffer districts, the value of the buffer land will fall the closer it gets to higher density exurban districts because of spillovers. On the other side of the boundary, the value of higher density exurban land would rise the closer it is to the exurban buffer districts because it should capitalize the quasi-public benefits that those districts offer. This is the desirable interactive outcome. Undesirable outcomes would be revealed if exurban buffer land values increased closer to the boundary, reflecting expectations by landowners of conversion to higher density exurban uses.

Cultivating the Preservation Hybrid

Fully effective farmland preservation policies have eluded local and state governments. Many have unwittingly accelerated the conversion of farming districts to hobby farms or low-density urban subdivisions. There is evidence that urban land is overvalued through government development subsidies, inefficient utility provision, and other market distortions induced by policy and inherent market imperfections. Farmland is undervalued for the same reasons and because of urban spillovers. In result, vastly more farmland is removed from production than should occur. Moreover, just a small reduction in farmland productivity can undermine the critical mass of farming infrastructure needed to sustain viable operations in a region. Perhaps, as Daniels (1990) observes, the best way to preserve farmland is to generate greater income for farmers. Sweden guarantees prices for farmers so they can outbid urban developers for the best farmland (Lapping 1979). Sweden also employs sophisticated new town and urban expansion planning. But the U.S. lacks a clear national policy toward the preservation of prime farmland, especially in the face of urbanization, and, therefore, state and local governments are left to their own devices to protect their long-term interests in farmland.

State and local governments are limited in their economic and legal capabilities. They cannot alter food prices. They cannot interfere with federal policies that raise or lower commodity supports. They cannot afford the purchase of the development rights of farmland—nor should they. The most effective farmland preservation tools available to state and local governments are land use planning and development regulation. The most effective mix are those used by Oregon plus the modifications proposed here.

NOTES

1. See Brown and Roberts (1978) on the role of local, state, and federal policies in stimulating inefficient land owner behavior and, implicitly, the need for land use regulatory mechanisms to compensate for these inefficiencies. See also Harvey and Clark (1965), Clawson (1962), and Nelson (1990a).
2. It is not known the extent to which farm subsidy policies offset urban subsidies. While total federal government commodity support policies totaled less than $20 billion in 1989, federally backed mortgage loans issued in 1989 exceeded $150 billion. According to the *1991 Statistical Abstract of the United States*, more federally backed home loans were delinquent in 1989 than all commodity price support policies in 1989 combined.
3. Farmers pay for those new facilities and services on the basis of land value, but not on whether they use them.
4. This figure is adapted from Nelson 1986a, 1990a.
5. For an extensive review of all common farmland preservation techniques see Nelson (1990a), a reply by Daniels (1990), and a rejoinder (Nelson 1990c).
6. Some farmers who enroll in those programs produce less than farmers who do not. While farmers realize a reduction in the cost of operations and this raises net revenues, it does not pressure them into making their land more productive (Bahl 1968; Goldberg and Chinloy 1984; Mills and Hamilton 1988). When urban development leapfrogs over farmland enrolled in a property tax relief program, the volume of land made underproductive increases.
7. Most right-to-farm laws also limit the ability of public agencies to condemn farmland for public works projects that can adversely affect the viability of farming districts.
8. At the heart of right-to-work laws is the desire to protect innocent farmers from land use actions or restrictions over which they have little or no control (Leutwiler 1986). These laws make it difficult for

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nearby nonfarm residents to restrict operations through nuisance suits. There are many shortcomings, however. Right-to-farm laws do not prevent farmers from converting their land to an urban use or prevent the sale to speculators; may not apply to the operations of new owners; and do not protect changes in agricultural practices (Lapping and Leutwiler 1987). Farmland that is fallow during the year in which new development occurs nearby may not be protected when actively farmed.

9. If these programs can succeed in protecting a critical mass of land, they can help sustain the agricultural infrastructure. In Montgomery County, Maryland, for example, the TDR program may have transferred sufficient development rights from large areas considerable distances to create the necessary critical mass to sustain agriculture into the long-term future.
10. PDR programs, because they are voluntary, suffer from the same limitations as TDR programs. They do not assure preservation of prime farmland in quantities and in locations suitable to sustain a viable agricultural economy. Nonparticipants remain free to farm or subdivide their land.
11. Incredibly, some farmers in Florida claim that one-acre minimum lot size zoning is perfectly acceptable in farming districts. They argue that higher minimum lot size zoning reduces land value, which reduces the amount they can borrow for agricultural purposes. The argument is specious. Farm loans do not exceed more than a certain percentage of the value of land for agricultural purposes. Moreover, with one-acre zoning, large-lot residential subdividing could not be prevented. Ironically, some farmers say they will volunteer not to subdivide and develop in return for the zoning. This promise would be difficult to enforce at best. Would a foreclosing lender be prevented from subdividing? Studies show that restrictive farm use zoning has not prevented farmers from securing agricultural loans in the amounts they would have received anyway (Coughlin 1984).
12. Nonexclusive agricultural zoning usually includes large minimum lot sizes; entitlement to single-family home construction on any preexisting and newly created but conforming lot; no requirement to demonstrate the effects on farm production of land partitioning at the minimum lot size; and conditional use permits allowing commercial recreation, smaller than minimum lot size developments, patently nonfarm dwelling units, agriculturally related industrial activities, and planned developments sometimes at higher densities.
13. The distribution has changed slightly since 1986 through continual fine tuning and plan revisions required by Oregon planning law.
14. The original criteria for determining whether land qualified for exception status were difficult to meet and carried a heavy burden of judicial review. Consequently, most plans failed to meet LCDC approval. Acceding to legislative demands, the LCDC replaced the original test with the impracticability test, which allows more flexibility in classifying rural land for exception status. One result has been a scattered and pervasive pattern of exception lands throughout the state.
15. Lapping (1980), Healy and Short (1981), and Buttel (1982) observe that hobby farmers often purchase more land than they are able to put to productive use; are generally unwilling or unable to make the investment in farm equipment and labor necessary to produce a commercial volume of farm products; compete with commercial farms for the same land, causing fragmentation of land holdings, driving land prices upward beyond what can be paid for out of a farm income; are a source of vandalism on nearby commercial operations and a cause of legal attempts to limit commercial farming practices; and create in commercial farmers questions of the future viability of farming, making them less willing to undertake long-term investments. As commercial farmers go out of business, an area can lose the "critical mass" of farms and farmers needed to maintain agricultural support services.
16. The framers of Oregon's farmland preservation program did not anticipate the magnitude of the demand for hobby farms. Between 1978 and 1982, Oregon led the nation in the formation of hobby farms and many analysts expressed concern that the trend would undermine Oregon's farmland preservation policies (Nelson 1983a; 1983b; Daniels and Nelson 1986; Daniels 1986).
17. The finding also indicates that even at twenty-acre minimum lot size restrictions, exurban development can be expected to impose negative spillovers onto farmland. The question now becomes: At what minimum density should we expect no statistically meaningful impacts of exurban development on farmland value? Would it be forty acres? Eighty acres?
18. Census tabulations do not adjust for inflation.
19. Willamette Valley includes Benton, Clackamas, Lane, Linn, Marion, Multnomah, Polk, Washington, and Yamhill counties.
20. Proper urban containment planning results in public facility and service savings (Nelson and Knaap 1987; Nelson 1987); improved delivery of social services; more efficient transportation systems (Newman and Kenworthy 1989); improved interaction among economic activities; lower housing package costs, although with possibly higher density and lower housing space (Real Estate Research Corporation 1974; Frank 1989); lower energy costs (Keyes and Peterson 1977); more efficient government management, assuming flexible management schemes such as interlocal cooperative agreements (Nelson 1991b); improved interaction between social classes (Jacobs 1961); improved sense of place (Lynch 1983); and, of course, preservation of open spaces outside urban development for farming, forestry, recreation, flood

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control, air cleansing, watershed, and related purposes.

21. Alas, all urban areas allow subdivision of future urbanizable land into one- to two-acre tracts. Although subdivision plans must include homesite locations that theoretically enable wise redivision in later years, the practical effect is to condemn future development in these areas to hodgepodge in-fill that residents are likely to oppose.
22. Some larger urban areas received approval for more land inside UGBs than strictly needed for development, arguing that more land was needed to prevent monopolistic behavior among landowners and to provide adequate locational choices for developers. The Portland UGB contained 15.8 percent more land than strictly needed and Salem's UGB contained 25 percent more than needed.
23. In mid-1992, the LCDC adopted the "urban reserve" rule, which would effect a few of the points argued in this article. By the mid-1990s, seven urban areas, including metropolitan Portland, will identify areas for UGB expansion, mostly on exception lands but also on selected prime farm and forest lands. Although not to be included in the UGB initially, lands placed into the urban reserve would be managed in such a way as to make urban expansion more efficient. In effect, this rule creates a longer term UGB, somewhat akin to the ultimate UGB proposed here.

REFERENCES

Archer, R. W. 1977. Policy and Research Issues in Subdivisions for Rural Residences, Hobby Farms, and Rural Retreats. Paper presented at the 48th ANZAAS Congress, Melbourne, Australia.

Bahl, Roy W. 1968. A Land Speculation Model: The Role of the Property Tax as a Constraint to Urban Sprawl. *Journal of Regional Science* 8, 2.

Berry, David. 1976. *Idling of Farmland in the Philadelphia Region, 1930–1970.* Regional Science Research Institute Discussion Paper Series No. 88. University of Massachusetts, Amherst.

Berry, David. 1978. Effects of Urbanization on Agricultural Activities. *Growth and Change* 9, 3: 2–8.

Berry, David, Ernest Leonardo, and Kenneth Bieri. 1976. *The Farmer's Response to Urbanization.* Regional Science Research Institute Discussion Paper Series No. 92. University of Massachusetts, Amherst.

Berry, David, and Thomas Plaut. 1978. Retaining Agricultural Activities Under Urban Pressures: A Review of Land Use Conflicts and Policies. *Policy Sciences* 9: 153–78.

Boal, Frederick W. 1970. Urban Growth and Land Value Patterns. *Professional Geographer* 22, 2: 79–82.

Bradbury, Dana Ann. 1986. Suburban Sprawl and the Right to Farm. *Washburn University Law Review* 22: 448–68.

Brown, H. James, and Neal A. Roberts. 1978. *Landowners at the Urban Fringe.* Discussion Paper D78–10. Cambridge, MA: Harvard University, Department of City and Regional Planning.

Buttel, F. H. 1982. The Political-Economy of Part-Time Farming. *GeoJournal* 6: 293–300.

Clawson, Marion. 1962. Urban Sprawl and Speculation in Suburban Land. *Land Economics*: 99–111.

Correll, Mark R., Jane H. Lillydahl, and Larry D. Singell. 1978. The Effects of Greenbelts on Residential Property Values. *Land Economics* 54, 2: 207–17.

Coughlin, Robert. 1984. *Evaluation of the Effect of Farm Use Zoning on the Ability of Farmers to Secure Farm Loans.* Philadelphia: University of Pennsylvania, Regional Science Research Institute.

Currier, Barry A. 1978. An Analysis of Differential Taxation as a Method of Maintaining Agricultural and Open Space Land Uses. *University of Florida Law Review* 30, 5: 821–42.

Daniels, Thomas L. 1986. Hobby Farming in America: Rural Development or Threat to Commercial Agriculture? *Journal of Rural Studies* 2, 1: 31–40.

———. 1990. Policies to Preserve Prime Farmland in the USA: A Comment. *Journal of Rural Studies* 6: 331–6.

Daniels, Thomas L., and Arthur C. Nelson. 1986. Is Oregon's Farmland Preservation Program Working? *Journal of the American Planning Association* 52, 1: 22–32.

Davis, Judy S. 1990. *Commuting Patterns of Exurban Households.* Center for Urban Studies, Portland State University, Portland, OR.

Davis, Judy S., Arthur C. Nelson, and Kenneth J. Dueker. 1993. The New 'Burbs. *Journal of the American Planning Association.* Forthcoming.

Forkenbrock, David J., and Peter S. Fisher. 1983. Tax Incentives to Slow Farmland Conversion. *Policy Studies Journal* 11: 25–37.

Frank, James E. 1989. *The Costs of Alternative Development Patterns.* Washington, DC: Urban Land Institute.

Fuller, Anthony M., and Julius A. Mage, eds. 1975. *Part-Time Farming.* Proceedings of the First Rural Geography Symposium. Guelph, Ontario: University of Guelph.

Furuseth, Owen J. 1980. The Oregon Agricultural Protection Program: A Review and Assessment. *Natural Resources Journal* 20: 603–14.

———. 1981. Update on Oregon's Agricultural Protection Program: A Land Use Perspective. *Natural Resource Journal* 21: 57–70.

Furuseth, Owen J., and John T. Pierce. 1982. *Agricultural Land in Urban Society.* Chicago, IL: Association of American Geographers.

Goldberg, Michael, and Peter Chinloy. 1984. *Urban Land Economics.* New York: John Wiley and Sons.

Gottmann, Jean. 1961. *Megalopolis.* New York: Twentieth Century Fund.

Gustafson, Greg C., Thomas L. Daniels, and Rosalyn P. Shirack. 1982. The Oregon Land Use Act. *Journal of the American Planning Association* 48, 3: 365–73.

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Hagman, Donald C., and Julian Conrad Juergensmeyer. 1987. *Urban Planning and Land Development Control Law.* St. Paul, MN: West Publishing.

Harvey, Robert O., and W. A. V. Clark. 1965. The Nature and Economics of Urban Sprawl. *Land Economics* 41, 1.

Healy, Robert G., and James L. Short. 1981. *The Market for Rural Land: Trends, Issues, Policies.* Washington, DC: The Conservation Foundation.

Jacobs, Jane. 1961. *The Death and Life of Great American Cities.* New York: Random House.

Keene, John C. et al. 1975. *Untaxing Open Space.* Washington, DC: Council on Environmental Quality.

Keyes, Dale L., and George R. Peterson. 1977. *Metropolitan Development and Energy Consumption.* Washington, DC: The Urban Institute.

Knaap, Gerrit J. 1982. The Price Effects of an Urban Growth Boundary. Dissertation, University of Oregon, Eugene.

_____. 1985. The Price Effects of an Urban Growth Boundary in Metropolitan Portland, Oregon. *Land Economics* 61, 1: 26–35.

Knaap, Gerrit J., and Arthur C. Nelson. 1988. The Effects of Regional Land Use Control in Oregon: A Theoretical and Empirical Review. *The Review of Regional Studies* 18, 2: 37–46.

_____. 1992. *The Regulated Landscape.* Cambridge, MA: Lincoln Institute of Land Policy.

Land Conservation and Development Commission (LCDC). 1986. *Oregon Lands.* Salem, OR: Department of Land Conservation and Development.

_____. 1989. *Report to the Oregon Legislature.* Salem, OR: Department of Land Conservation and Development.

_____. 1990. *State Planning Goals and Guidelines.* Salem, OR: Department of Land Conservation and Development.

Lapping, Mark B. 1979. Agricultural Land Retention Strategies: Some Underpinnings. *Journal of Soil and Water Conservation* 34: 124–6.

_____. 1980. Agricultural Land Retention: Responses Foreign and American. In *The Farm and the City: Rivals or Allies?,* edited by A. M. Woodruff. Englewood Cliffs, NJ: Prentice-Hall.

Lapping, Mark B., and J. F. FitzSimmons. 1982. Beyond the Land Issue: Farm Viability Strategies. *GeoJournal* 6: 519– 24.

Lapping, Mark B., and Nels R. Leutwiler. 1987. Agriculture in Conflict: Right-to-Farm Laws and the Pari-Urban Milieu for Farming. In *Sustaining Agriculture in Cities,* edited by William Lockeretz. Ankeny, IA: Soil and Water Conservation Society of America.

Lee, Douglass B. 1979. Market Failure. *The Land Use Policy Debate in the United States.* New York: Praeger.

Leutwiler, Nels R. 1986. Farmland Preservation Laws: What Do They Do? Can They Be Justified? Master's thesis, Department of Urban Planning, University of Colorado at Denver.

Lynch, Kevin. 1983. *Theory of Good Urban Form.* Cambridge, MA: MIT Press.

Meier, Bruce W. 1988. An Urban Induced Ring of Disinvestment by Farm Operators. Paper presented to the Association of American Geographers, Miami University, Miami, Ohio.

Mills, Edwin S., and Bruce W. Hamilton. 1988. *Urban Economics.* 4th ed. Homewood, IL: Scott Foresman.

National Agricultural Lands Study (NALS). 1981. Washington, DC: U.S. Department of Agriculture.

Nelson, Arthur C. 1983a. Comment on the Oregon Land Use Act. *Journal of the American Planning Association* 49, 1: 85–7.

_____. 1983b. Comment. *Natural Resources Journal* 23, 1: 1–5.

_____. 1984. *Evaluating Urban Containment Programs.* Portland, OR: Center for Urban Studies, Portland State University.

_____. 1985. A Unifying View of Greenbelt Influences on Regional Land Values and Implications for Regional Policy. *Growth and Change* 16, 2: 43–8.

_____. 1986a. Using Land Markets to Evaluate Urban Containment Programs. *Journal of the American Planning Association* 52, 2: 156–71.

_____. 1986b. Toward a Theory of the American Rural Residential Land Market. *Journal of Rural Studies* 2, 4: 309–19.

_____. 1987. The Effect of a Regional Sewer Service on Land Values, Growth Patterns, and Regional Fiscal Structure Within a Metropolitan Area. *Urban Resources* 4, 2: 15– 8, 58–9.

_____. 1988. An Empirical Note on How Regional Urban Containment Policy Influences an Interaction Between Greenbelt and Exurban Land Markets. *Journal of the American Planning Association* 54, 2: 178–84.

_____. 1990a. Economic Critique of Prime Farmland Preservation Policies in the United States. *Journal of Rural Studies* 6: 114–42.

_____. 1990b. Blazing New Planning Trails in Oregon. *Urban Land.* Washington, DC: Urban Land Institute.

_____. 1990c. The Analytic Basis for Farmland Preservation. *Journal of Rural Studies* 6: 337–46.

_____. 1991. Toward a Definition of Exurbia. *Journal of Planning Literature* 6, 4: 350–68.

_____. 1992. Lessons of Urban Growth Boundary Design and Management in Oregon. *Real Estate Finance* 58, 4: 11–22.

Nelson, Arthur C., and Kenneth J. Dueker. 1989. Exurban Living Through Advanced Technology. *Journal of Urban Planning and Development* 115, 3: 101–13.

_____. 1990. The Exurbanization of America with Notable Planning Policy Implications. *Journal of Planning Education and Research* 59, 2: 91–100.

Nelson, Arthur C., and J. Richard Recht. 1988. Inducing the Residential Land Market to Grow Timber in an Antiquated Rural Subdivision. *Journal of the American Planning Association* 54, 4: 529–36.

Newman, Peter, and Jeffrey Kenworthy. 1989. *Cities and Automobile Dependence.* Sydney, Australia: Gower.

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Pacific Meridian Resources. 1991. *Analysis of the Relationship of Resource Dwelling and Partition Approvals Between 1985–87 and Resource Management in 1990.* Salem: Oregon Land Conservation and Development Commission.

Platt, Rutherford H. 1985. The Farmland Conversion Debate. *Professional Geographer* 37, 4: 433–42.

Plaut, Thomas. 1976. *The Effects of Urbanization on the Loss of Farmland at the Rural-Urban Fringe: A National and Regional Perspective.* Regional Science Research Institute Discussion Paper Series No. 94. University of Massachusetts, Amherst.

Pope, C. Arden. 1985. Agricultural Productive and Consumptive Use Components of Rural Land Values in Texas. *American Journal of Agricultural Economics* 66, 1: 81–6.

Prestbo, John, ed. 1975. *This Abundant Land.* Princeton, NJ: Dow Jones Books.

Real Estate Research Corporation. 1974. *The Costs of Sprawl.* Chicago, IL: Real Estate Research Corporation.

Rose, Jerome B. 1984. Farmland Preservation Policy and Programs. *Natural Resources Journal* 24, 3: 591–640.

Rosser, J. Barkley, 1978. The Theory and Policy Implications of Spatial Discontinuities in Land Values. *Land Economics* 54, 4: 430–41.

Sinclair, Robert. 1967. Von Thuenen and Urban Sprawl. *Annals of the Association of American Geographers* 57: 72–87.

Solomon, Barry. 1984. Farmland Protection: A Case of Quality Not Quantity. *Land Use Policy*: 357–66.

United States Department of Agriculture. 1985. *1982 Census of Agriculture.* Washington, DC: U.S. Government Printing Office.

———. 1990. *1987 Census of Agriculture.* Washington, DC: U.S. Government Printing Office.

Vining, Daniel R., Kenneth Bieri, and Ann Strauss. 1977. *Urbanization of Prime Agricultural Land in the United States: A Statistical Analysis.* Regional Science Research Institute Discussion Paper Series No. 99. University of Massachusetts, Amherst.

Vining, Daniel R., Thomas Plaut, and Kenneth Bieri. 1977. Urban Encroachment on Prime Agricultural Land in the United States. *International Regional Science Review* 2, 2.

Volkman, Nancy J. 1987. Vanishing Lands in the USA. *Land Use Policy* 4, 1: 14–30.

Zeimetz, Kathryn A., Elizabeth Dillon, Ernest E. Hardy, and Robert C. Otte. 1976. *Dynamics of Land Use in Fast Growth Areas.* Agricultural Economics Report No. 325. Economic Research Services, United States Department of Agriculture, Washington, DC.

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Blame the exurbs, not the suburbs: Exploring the distribution of greenhouse gas emissions within a city region

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HIGHLIGHTS

- Household survey data and GPS-verified travel data are used to estimate GHG emissions.
- Residential location impacts both transportation and housing-related GHG emissions.
- Results reveal spatial variability in direct GHG emissions at the sub-regional scale.
- No significant difference in total direct GHG emissions between urban and suburban respondents.
- Travel related GHG emissions are significantly higher among those living in the exurbs.

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ABSTRACT

This research investigates whether where we live matters in terms of contributions to direct greenhouse gas (GHG) emissions. Using results from the Halifax Space Time Activity Research (STAR) project, we estimate GHG emissions for 1920 randomly selected respondents in Halifax Regional Municipality, Nova Scotia, Canada. The unique data set allows us to report direct GHG emissions with an unprecedented level of specificity at the sub-regional scale using household energy-use survey data and GPS-verified travel data. We report results and investigate statistical differences between communities and urban–rural zones (inner city, suburban, and inner and outer commuter belts). Results reveal considerable spatial variability in direct GHG emissions across the study area. Our findings indicate that individuals living in the suburbs generate similar amounts of GHG emissions (20.5 kg CO_2e person^{-1} day^{-1}) to those living in the inner city (20.2 kg CO_2e person^{-1} day^{-1}), challenging a widely held assumption that living in the urban centre is better for sustainability. However, individuals in more rural areas have significantly higher transport-related GHG emissions than those living in the inner city and suburbs. Our results underscore the importance of understanding the spatial distribution of GHG emissions at the sub-regional scale.

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1. Introduction

Influencing where people live is a strategy available to municipalities for reducing household greenhouse gas (GHG) emissions. The objective has been to increase the population density of the urban core and curb urban sprawl (Parshall et al., 2010; Weisz and Steinberger, 2010). The rationale is based on a poorly tested, yet widely held, assumption that people living in the urban core have lower environmental impact lifestyles than do their suburban and rural counterparts (Hoornweg et al., 2011). The premises held that square-footage of houses are smaller in inner city zones, and that individuals are less vehicle-dependent than those living in the suburbs and rural fringes of urban regions. However, the relationship between the built environment and travel mode choice remains poorly understood (Ewing and Cervero, 2010). Furthermore, as most sustainability and land-use planning studies are urban-focused, the policy debate has focused on an urban (inner-city) versus suburban dichotomy. The suburbs are perceived as the locus of 'unsustainable' development and living, compared to the urban core (Hoornweg et al., 2011). In the North American context, however, the rapidly-developing "exurbs" of the urban fringe (Davis et al., 1994; Lamb, 1983; Nelson, 1991; Taylor, 2011) extend far into the quasi-rural commuter belt, and it is therefore also important to compare GHG emissions of exurbanites to those of urban and suburban residents.

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The notion that where we live influences our environmental impact has been an important meta-theme within the "smart growth" planning movement. Understanding of the distribution of GHG emissions across urban regions is, however, poor at best. Few studies report GHG emissions or carbon footprints at the sub-regional or sub-municipality scales. Lack of data at finer spatial scales presents a significant limitation for sustainability analysis (Wilson and Grant, 2009). Lenzen et al. (2004) and Haq and Owen (2009) estimate both energy consumption and carbon footprints at the sub-city level by linking input-output analysis with household spending survey data. Druckman and Jackson (2008) for the United Kingdom, and Weber, Matthews (2008) for the United States, estimate GHG emissions of households by income category and other household characteristics using models that link household expenditure data to energy consumption. Neither study specifies a geographic region, but their models could support a sub-regional analysis. In absence of input-output data, VandeWeghe and Kennedy (2007) estimate residential GHG emissions by census tract for the Toronto Census Metropolitan Area (Canada) based on household fuel payments and transportation survey data. Wilson et al. (2013) presents the most refined analysis to date, estimating the ecological footprint, including the carbon footprint, by Census Dissemination Area (400–700 people) for Oakville, Ontario (Canada). Ecological footprint values were derived using household energy use data, square footage data, household spending data, and commuting survey data.

The literature provides convincing evidence that environmental impacts vary substantially at the sub-city level. What is of interest, however, is to discern whether such variation is repetitive and predictable, and here the results are mixed. Wilson et al. (2013) found substantial variability in ecological footprints within what one might expect to be a relatively homogeneous group (the study community, Oakville, is a bedroom community of Toronto and considered a suburb in its entirety). In Oakville, higher footprint households tended to concentrate along the waterfront and green spaces indicative of higher-income households. Lenzen et al. (2004) found that energy requirements of subdivisions are higher nearer the city centre. Haq and Owen (2009) noted neighborhoods reporting the largest carbon footprints were in either the inner city or rural areas. VandeWegh and Kennedy (2007) found census tracts located in the suburbs had the highest per capita GHG emissions. All of these efforts, however, quantify the environmental impact of households based, in part, on spending data or other indicators. To the best of our knowledge, no studies have estimated GHG emissions (or similar measurement units, i.e. carbon footprint) based directly on energy use information collected at the household level.

The objective of the present analysis is to understand spatial variation in direct greenhouse gas emissions across an urban region based on household-specific energy use data and GPS-verified personal travel data. The unique dataset allows us to report direct GHG emissions with an unprecedented level of specificity at a sub-regional level. The analysis reports direct GHG emissions using for 1920 respondents living in Halifax Regional Municipality (HRM), Nova Scotia, Canada.

Results are reported by community, confirming variability in direct GHG emissions across HRM. In addition, results are reported by urban–rural zones, highlighting differences in direct GHG emissions between urban, suburban, and rural commuter zones.

2. Data and methods

2.1. Data

Our study employs data from the Halifax Space-Time Activity Research (STAR) project, which represented the world's largest deployment of global positioning system (GPS) technology for a household activity survey (Bricka, 2008). The Halifax STAR project sampled 1971 randomly selected households in HRM, or about one household in 78, between April 2007 and May 2008 (Time Use Research Program (TURP), 2008). HRM is the provincial capital of Nova Scotia and the largest municipality in Atlantic Canada, spanning almost 5500 square kilometers, with a population of over 390,000 people in 2007 (Statistics Canada, 2012). In many ways, HRM is highly representative of Canadian mid-sized metropolitan areas, having a diverse and moderately prosperous economy with population growth of about 0.5% per year. The study area has a clearly-defined downtown area that has experienced little inner city decay, and income variations across the region are modest. Low-density exurban sprawl is particularly evident in a commuter belt within 50 km of downtown Halifax, while very few people reside in the fully rural area beyond 50 km (Millward and Spinney, 2011a).

The Halifax STAR project collected time diary and questionnaire data over 373 days of data collection, with a cooperation rate of 25% and overall response rate of 21% (Millward and Spinney, 2011b). The primary sampling frame was all residential households with listed telephone numbers. A pre-notification letter was used to make initial contact with each household, followed by a recruitment telephone call. Using computer-assisted telephone interview (CATI) software, recruited households completed a brief intake questionnaire to collect age and other information for all household members. The age information was used to randomly select the secondary sampling unit; a single household member over the age of 15 who was randomly selected as the "primary respondent", and was assigned a consecutive pair of diary days (e.g. Thursday–Friday, Friday–Saturday, etc.). Throughout the 48-h reporting period, the primary respondent carried a GPS-device (Hewlett Packard iPAQ hw6955) that was programmed to collect GPS data every 2 s and automatically send that information back to a central server for processing. The "day after" the two-day reporting period, both questionnaire and two-day time diary data were collected using specially-designed computer-assisted telephone interview (CATI) software. The CATI software enables interviewers to visualize the GPS data, travel routes, and precise start and end times for all "stops" (i.e. stationary locations lasting at least two minutes). See Time Use Research Program (TURP), 2008, 2010a, and, 2010b for a detailed description of the sampling strategy, survey methods, and data user guide. The STAR survey was modeled after Statistics Canada's (2006) General Social Survey (GSS) Cycle 19, which asked questions about personal characteristics, household characteristics, neighborhood features, socio-economic data, and subjective dimensions of well-being. The STAR survey supplemented those questionnaire items with questions regarding electricity consumption, home heating, and energy efficiency behaviors, among others.

Using ArcGIS 9.3®, the geographic coordinates (latitude and longitude) of each household's residential location within the study area were "spatially joined" with communities (based on municipal administrative boundaries) and urban–rural zones (delimited operationally on the basis of both urban form and commuting linkages to the urbanized area). Given the measurement of transportation-related GHG emissions is based primarily on average travel distance, the zones defined by Millward and Spinney (2011a) are used in this study. These zones are based on street network travel distance outwards from "downtown", and, therefore, offer a more functional approach to examine the extent to which GHG emissions vary within the study region. The "inner city" of HRM is defined as the area within a 5 km travel distance of Halifax and Dartmouth's "downtown" areas. The "suburbs" are adjacent developed areas with city water and sewer services, mostly lying between 5 and 10 km from downtown. The "inner

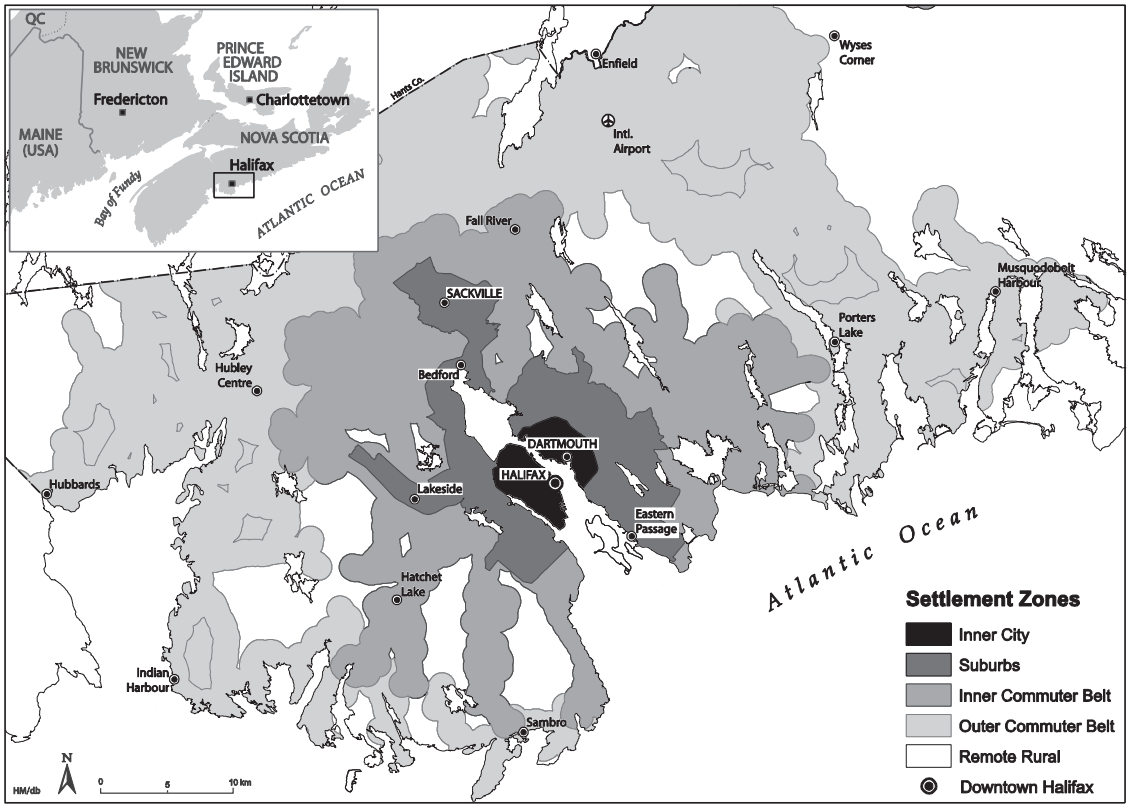


Fig. 1. Urban–Rural Zones in the Halifax Regional Municipality.

Table 1
Summary statistics for select survey items by urban–rural zone.

	Inner city *Mean (S.D.)*	**Suburbs** *Mean (S.D.)*	**Inner commuter belt** *Mean (S.D.)*	**Outer commuter belt** *Mean (S.D.)*
Age of respondents	55.3 (14.2)	52.6 (13.9)	48.7 (11.0)	48.9 (12.1)
Persons per household	2.5 (1.1)	2.7 (1.1)	3.1 (1.2)	2.9 (1.2)
Heated square feet	1983 (1128)	1979 (820)	2237 (915)	2177 (786)
Heated square feet per person	920 (626)	848 (505)	836 (514)	857 (443)
Number of household vehicles	1.4 (0.7)	1.7 (0.7)	2.1 (1.0)	2.0 (0.7)
Car-dependency (km/day)	25.8 (38.5)	32.6 (42.7)	49.3 (50.6)	53.2 (52.1)
Percent light duty vans and trucks (%)	21	31	34	38

commuter belt (ICB)" comprises unserviced communities lying between 10 and 25 km travel distance to downtown while the "outer commuter belt (OCB)" lies between 25 and 50 km to downtown. Millward and Spinney (2011a) define a fifth zone, "remote rural", which encompasses areas beyond 50 km travel distance to downtown, or lacking road access, but due to a lack of sample, we do not report GHG emissions for this zone (Fig. 1).

The STAR sample approximates a proportional distribution for gender, days of the week, and the months of the year. Spinney and Millward (2011) provides a detailed description of the sample. A few of the more pertinent survey items to the study are summarized and presented in Table 1 using measures of central tendency and dispersion that are stratified by urban–rural zone. The survey items that are summarized in Table 1 are respondents' ages; persons per household; housing size (heated square footage); heated square footage per person; number of household vehicles, "car-dependency" that is measured using daily mean travel distance (km) in a private vehicle or taxi; and the prevalence of light duty vans and trucks (bigger vehicles) as a percentage of vehicle fleet of respondents.

If we consider adjacent successive urban–rural zones as an ordinal classification of increasing distance from downtown, both household size and the number of persons per household increases as we move away from the inner city toward the inner and outer commuter belts. The heated square footage of households per person, however, decreases with increasing distance from the inner city. The mean heated square feet of housing increases with increasing distance from the inner city, but when the size of the home is adjusted for the size of the family, there appears to be an inverse relationship between heated square feet per person and increasing distance from the inner city. Both dwelling size and family size increase with distance from the inner city. There is a steady decline in the age profile with increasing distance from the inner city; average age decreases from a high of 55 years old in the inner city to 48 years old in the inner and outer commuter belts. More pronounced is the pattern of increasing car dependency (km traveled per day) with increasing distance from the inner city, and decreasing opportunities for alternate travel modes. About one-quarter of inner city respondents are car dependent. That value rises to about one-third in the

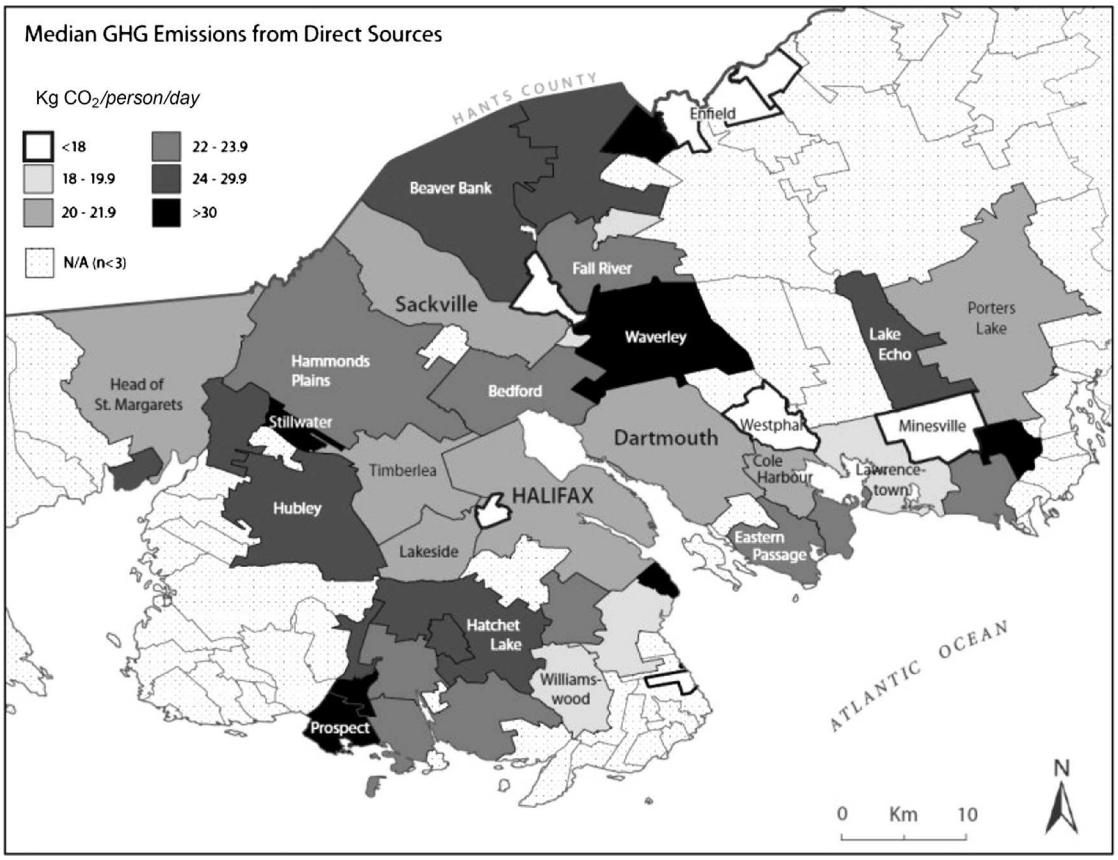


Fig. 2. Spatial distribution of median GHG estimates by communities.

suburbs, to almost one-half in the inner commuter belt, and exceeds one-half in the outer commuter belt. Not surprising then, the average number of vehicles per household also increases with increasing distance from the inner city, where the average is 1.4 vehicles per household and that number reaches its maximum in the inner commuter belt at 2.1 vehicles per household. In the same vein, there is a modest, but steady, increase in the prevalence of light-duty vehicles with increasing distance from the inner city to the rural countryside. Overall, however, we found little distinction in prevalence of light-duty vehicles between the inner and outer commuter belt zones.

2.2. Methods

Shelter-related and transportation-related direct GHG emissions were estimated per respondent per day in kilograms carbon dioxide equivalents (kg CO_2e person^{-1} day^{-1}). Shelter-related GHG emission estimates are based on respondent-recall of electricity bills, home heating bills, and amount of wood burned. Respondents were asked to consult bills, although we are not able to verify which houses did and did not. We reported shelter-related emissions per respondent by dividing the total household emissions by the number of household members. We confirmed results with an expert from the provincial energy efficiency agency, which resulted in 15 cases being screened out of our analysis, because of unreasonably high shelter-related energy use. For transportation-related direct GHG emissions, we estimated personal transportation based on distances traveled, using household activity survey data. Trip distances were computed using the shortest path between GPS-verified origins and destinations. Thirty-six respondents had incomplete travel data and were screened out of our analysis. Also, we do not include air travel in our estimation of GHG emissions, because many of the out-of-country coordinates were not captured in the STAR survey. In Nova Scotia, air travel (domestic aviation) represents approximately 7% of total transport-related GHG emissions (Environment Canada, 2010). For a more detailed description of specific methods and assumptions used to estimate direct GHG emissions, see Wilson et al. (in press).

Each respondent's residential location was used to summarize the spatial distribution of direct GHG emissions across the 62 communities within the study area. Communities, in this context, do not reflect a specific population size. Rather, they represent longstanding geographic areas with meaningful similarities in both perceptions and interpretations of both place and context. Median direct GHG emissions were calculated for communities with three or more sampled households and mapped using ArcGIS 10® to illustrate the spatial distribution of emissions. In addition, shelter-related, transportation-related, and total direct GHG emissions were assigned to urban–rural zones. Statistical Package for the Social Sciences (SPSS, v.15.0) software was used to measure the median and inter-quartile range (IQR) for GHG emissions by urban–rural zones. Medians were chosen in preference to means, because each of the three emission variables exhibit skewed distributions, which was confirmed by the Kolmogorov–Smirnov *Z* test. We tested two-tailed significance of differences among adjacent successive urban–rural zones using a Mann–Whitney *U* test. The *U*-test is a non-parametric difference-of-ranks test that tests whether two independent samples of observations are drawn from the same distribution, and it is employed in preference to the two-sample *t*-test because the distributions of the variables under scrutiny are skewed.

3. Results

In total, direct GHG emissions were estimated for 1920 respondents. We omitted 51 of the 1971 households due to incomplete or

problematic data specific to this research. Statistical analysis of the STAR household data indicates the median total direct GHG emissions for HRM is 21 kg CO_2e person^{-1} day^{-1}, with a range of 101 kg, and inter-quartile range of 14 kg. On average, provision of electricity and home heating contribute 78% of direct GHG emissions with a mean of 14.6 kg CO_2e person^{-1} day^{-1}, which is significantly higher ($p = < 0.001$) than emissions associated with personal transportation, which account for the balance of direct GHG emissions and average 4.1 kg CO_2e person^{-1} day^{-1}.

3.1. Greenhouse gas emissions by community

A total of 44 communities have three or more households with estimates of direct GHG emissions (Fig. 2). We found variability in direct GHG emissions across the HRM, with median values ranging from 13.9 to 35.8, and a median value across all communities of 21 kg of CO_2e person^{-1} day^{-1}. In general, median GHG emissions per person tend to increase as we move toward the perimeter of the HRM, although that pattern does not appear consistent. For example, the communities of Stillwater and Waverley both have very high emissions (> 30 kg CO_2e person^{-1} day^{-1}) while the community of Westphal has very low median emissions (< 18 kg CO_2e person^{-1} day^{-1}) (Fig. 2). The overall pattern is that communities in the commuter belt tend to have higher values than the inner-city or suburbs, and it is noteworthy that all communities with median direct emission values over 24 kg CO_2e person^{-1} day^{-1} lie in the exurban commuter area. Relatively high per capita daily emission values (> 24) are noted for wealthier commuter-belt communities, such as Waverley, Stillwater, and Oakfield, while relatively lower emission values (< 20) in the commuter belt tend to occur in medium or low-medium income areas, such as Enfield, Lawrencetown, and Williamswood. These community-level patterns echo results produced previously by Wilson et al. (2013) for the town of Oakville, Ontario. However, some community-level median emission values are based on few observations, which prevents significance testing. To allow such testing, we turn to an examination of zonal differences along the urban–rural continuum.

3.2. Greenhouse gas emissions by urban-rural zone

To further elucidate the spatial distribution of shelter-related, transportation-related, and total direct GHG emissions across the study area, we present median and IQR emissions per person per day by urban–rural zone in Table 2. In addition, in Table 2, we report Mann–Whitney U test results of differences between adjacent successive urban–rural zones.

Results in Table 2 indicate that total emissions increase away from the urban core; median daily direct GHG emissions for respondents living in the inner and outer commuter belt zones are approximately 11% higher than for respondents living in the inner city zone. Interestingly, there is little difference (< 2%) in median direct GHG emissions between the inner city zone and the suburban zone, and any difference appears purely due to chance. For total direct GHG emissions, the only significant difference ($p = 0.003$) between adjacent successive zones is for the suburbs and ICB, the suburbs being lower. Basically, the results in Table 2 illustrate that as we move away from the inner city zone, there is a decrease in shelter-related emissions and an increase in transportation-related emissions.

Results in Table 2 indicate that the overall median transportation-related GHG emissions are 4.1 kg CO_2e person^{-1} day^{-1}. Our sample indicates that private vehicle use contributes about ninety-nine percent (99%) of direct GHG emission associated with personal transportation. Transportation-related GHG emissions increase from the inner city (2.2 kg CO_2e person^{-1} day^{-1}) to the suburbs (4.0 kg CO_2e person^{-1} day^{-1}), and another increase to the inner commuter belt (6.2 kg CO_2e person^{-1} day^{-1}). Despite another increase (0.9 kg CO_2e person^{-1} day^{-1}) from the inner to the outer commuter belt, values for these two zones are not significantly different (Table 2). Any increase in transportation-related emissions moving outwards from the inner city appears to be offset by significantly reduced shelter-related emissions. Results in Table 2 indicate that significantly lower shelter-related emissions were reported in the suburbs (14.6 kg CO_2e person^{-1} day^{-1}) compared to the inner city (16.2 kg CO_2e person^{-1} day^{-1}), and significantly lower again in the inner commuter belt (13.6 kg CO_2e person^{-1} day^{-1}). Just like travel-related emissions, shelter-related emissions are not statistically different between respondents living in inner and outer commuter belts.

Table 2
Median direct greenhouse gas emissions, kg CO_2e person^{-1} day^{-1}.

Zone	*N*	Total direct GHG *Median (IQR)*	Transportation-related GHG *Median (IQR)*	Shelter-related GHG *Median (IQR)*
Overall	1920	20.8 (14.1)	4.1 (7.0)	14.6 (10.0)
Inner city	382	20.2 (12.6)	2.2 (3.9)	16.2 (10.5)
Significance		0.382	< 0.001	0.026
Suburbs	1039	20.5 (13.5)	4.0 (6.1)	14.6 (10.0)
Significance		0.003	< 0.001	0.023
Inner commuter belt	334	22.9 (15.4)	6.2 (9.1)	13.6 (9.5)
Significance		0.944	0.513	0.818
Outer commuter belt	165	22.0 (19.6)	7.1 (11.4)	13.4 (8.2)

4. Discussion

The present analysis complements previous sub-city environmental impact analyses by reporting direct GHG emissions using household-specific energy use data and GPS-verified travel data for 1920 respondents living in HRM. Our unique dataset allows us to report direct GHG emissions with an unprecedented level of specificity at a sub-regional level. The data demonstrate a wide range in direct GHG emissions by respondent, reflective of the sampling strategy and consistent with trip diary data. Data collection occurred over a 1-year period. Depending on the time of year, households could have very different home energy use demands. Further, with respect to personal transportation, large ranges in travel distances are consistent with trip diary surveys (Kang and Scott, 2010). While individual travel events may appear to be atypical for the person undertaking them (e.g., the case of visiting a distant relative), taken in aggregate they accurately represent variability in GHG emissions based on people's activities, which take place at disparate locations. Not all trip purposes are repetitive (as is the case for travel to and from work). Rather, there exists considerable variability in activities and travel across days of the week (Kang and Scott, 2010).

Our analysis is not without its limitations. For example, it reports GHG emissions per respondent, because the travel data are based on a personal, wearable, GPS collection device. Conceptualizations of urban regions in terms of households may be a more functional unit. It would also help mitigate issues of attribution of transportation-related GHG emissions if other household members are present in the vehicle. For example, what is the appropriate approach to split the associated GHG emissions if the trip purpose is taking a child to sports practice or if a child is present on a shopping trip? A potential research direction could be to incorporate out-of-home activity diary data from other household

members, which could be used to identify if and why other household members are present in the vehicle. Using trip purpose by travel segment could provide a useful mechanism for mitigating attribution issues.

Although studies suggest that indirect emissions contribute 40–65% of total GHG emissions associated with typical Western lifestyles (Benders et al., 2006; Kok et al., 2006; Moll et al., 2005; Nansai et al., 2008; Weber and Matthews, 2008), our analysis does not include indirect GHG emissions. Indirect GHG emissions refer to the emissions that result from earlier stages in the life cycle of the goods and services that we consume and correlate strongly with income (Benders et al., 2006; Druckman and Jackson, 2008; Lenzen et al., 2004; Weber and Matthews, 2008). We considered including indirect emissions by allocating regional input–output data to households by income category, using household expenditure survey data. We decided not to, however, to avoid estimating sub-city results by extrapolating from national-level data. Further, HRM does not appear to have a high concentration of higher-income households in one specific zone. In the sample, all zones reported a median personal income range category of $40,000–$59,999. Future research will look at including indirect GHG emissions.

Our results illustrate the patterning of GHG emissions within a city region at an exceptional spatial scale. These fine-resolution results offer planners and policy makers a unique perspective regarding variation in GHG emissions at a sub-city level. The community-level mapping, for example, revealed considerable variation in emissions at the local level, consistent with other sub-city analyses of environmental impacts (Haq and Owen, 2009; VandeWeghe and Kennedy, 2007; Wilson et al., 2013) and challenges the notion of a simple gradient in increasing emissions moving outward from the urban core. Although peripheral communities tend to show higher median total emissions, these medians also seem to relate to income levels, with wealthier communities showing higher values (Wilson et al., in press). Small sample sizes in many rural communities, however, prevented the use of significance testing.

Shelter-related emissions per person decrease as we move away from the inner city toward the outer commuter belt. While houses become bigger as we move outward from the inner city, to the commuter-belt zones, the STAR sample indicates there are more people per household (Table 1). When we factor in number of persons per household, therefore, the square footage per person is very similar in all zones except the inner city, where it is noticeably larger. This may reflect the “empty-nest” characteristic of many inner-city households, compounded by under-sampling of renters, such as students and those with lower incomes.

We feel reporting results by urban–rural zone to be a more useful approach for analyzing direct GHG emissions at the sub-city level than reporting by community. The zones organize the municipality based on urban form and distance to the regional centre, which are both widely perceived factors influencing energy consumption patterns. Categorizing HRM by zone can support policy and planning decisions that cater to different challenges and opportunities faced by each zone to reduce GHG emissions. For example, public transportation either does not service or poorly services the inner and outer commuter zones, limiting travel options. Also, the housing stock in the urban core is typically older than in the suburban and commuter zones, presenting different challenges to reducing shelter-related GHG emissions. The lack of significant differences between inner and out commuter belt zones in direct, transportation-related, and shelter-related emissions, plus select survey items, suggesting remarkable similarities among these two regional groups of respondents.

Our results for HRM show little difference in per capita direct GHG emissions between the inner city and the serviced suburbs, challenging a widely-held assumption that inner city living is inherently more sustainable than suburban living. The notion that inner city living is ‘greener’ is partially based on the assumptions that people in the inner city drive less and live in smaller households (square footage). We did find that those living in the suburbs had higher median transportation related GHG emissions. Respondents in the suburbs, on average, traveled more per day as the driver or passenger of a private vehicle (Table 1) and drove bigger vehicles (SUV, van, pick-up) as a percentage of the total vehicle fleet. Median transportation related GHG emissions of respondents living in the inner city are 2.2 kg CO_2e person^{-1} day^{-1} compared to 4.0 kg CO_2e person^{-1} day^{-1} for respondents living in the surburbs. Our dataset, however, does not support the assumption of bigger homes and higher shelter related GHG emissions in the suburbs in comparison to the inner city. Average heated square footage of households was remarkably similar. When we consider square footage per household member, it was less in the suburbs compared to the inner city. Median shelter related GHG emissions of respondents living in the inner city are 16.1 kg CO_2e person^{-1} day^{-1} compared to 14.6 kg CO_2e person^{-1} day^{-1} for respondents living in the surburbs. Lower GHG emissions associated with electricity use and home heating in the suburbs offset the higher transportation related emissions.

In HRM, heating and electricity related emissions dominate direct GHG emissions accounting for 78% of total GHG emissions. The substantial contribution of heating and electricity to overall emissions can be explained in part by Halifax′s reliance on oil and electricity as a primary heating source coupled by the fact that the greenhouse gas intensity of electricity generation in the province is high, over triple the Canadian average. Additionally, in comparison to other regions in Canada, the housing stock is older and there are more single-family dwellings as a percentage of the total housing stock (77% vs. 58%) (Natural Resources Canada (NRCAN), 2010). In comparison, jurisdictions relying on hydro generated electricity and heating primarily with natural gas would have lower associated household GHG emissions. If GHG emissions associated with shelter were lower, the difference in transportation related emissions would be more pronounced in terms of influencing overall emissions. As the province of Nova Scotia moves toward lower-carbon electricity, shelter-related emissions should decline placing greater emphasis on transportation related emissions.

The dynamics driving transportation related GHG emissions are not straight-forward. For example, the notion of a single travel flow from suburbs to inner city for work and shopping in the HRM context is incorrect. In the case of HRM, several major industrial-business hubs are located in the suburbs. Ninety-six percent of new office space between 2008 and 2012 was built in the suburbs indicating a decreasing need to enter the downtown core for work (Our HRM Alliance, 2012). Further, those living in the urban core may travel to suburbs to access services and shopping creating a reverse travel requirement. Assuming that inner city living is inherently more sustainable than suburban living masks that both zones present sustainability challenges that require attention. In the case of HRM, the inner city is dealing with a number of critical issues: high carbon electricity and heating sources, inefficient homes, low population density, large housing size per person, low public transit use, and an infrastructure that favours travel to suburban zones for shopping, services, and potentially even employment.

Efforts to reduce greenhouse gas emissions must also include the exurbanites. Those living in commuter belt zones and on the rural fringe have substantially higher greenhouse gas emissions, and particularly higher transport-related direct GHG, which often get

overlooked in a policy debate that has focused on an urban (inner-city) versus suburban dichotomy. The exurbs of the commuter belt are characterized by low-density, large-lot development, lacking city water and sewer services. Though commuter-dependent, they have the appearance of rurality, and provide sought-after environments for family living (Millward, 2006). However, lack of public transport, and limited options for active transport, lead to greater car-dependency and longer trip distances per person, such that transport-related direct emissions are three times those in the inner city, and 1.5 times those in the suburbs. Interestingly, median transport-related GHG estimates for the inner and outer commuter zones are virtually the same, which is likely due to transport-minimizing accommodations made by outer commuter belt residents, reported by Millward and Spinney (2011a). In particular, respondents in the outer commuter belt make significantly fewer car trips than those in the inner commuter belt, though average trip duration is slightly longer.

5. Conclusion

Policy and planning efforts to reduce the carbon footprints of our cities requires an understanding of the variability in household environmental impacts within a community (Wilson et al., 2013). The STAR data provide a more nuanced perspective on direct GHG emissions than previously available, particularly because they reflect accurate and precise location information. Analysis of these data by urban–rural zones offers a functional categorization around which to frame GHG reduction strategies. Findings challenge the assumption that development patterns outside of the urban core, notably in the serviced suburbs, are inherently less sustainable and/or detrimental to sustainability. The assumptions that those living in the suburbs have bigger homes, bigger cars, and drive more are only partially correct. We did find bigger cars and higher transportation-related GHG emissions, but lower shelter-related emissions appear to offset them. Shelter-related emissions account for 70% of total GHG emissions, on average. We do, however, see a noticeable increase in direct GHG emissions for the inner and outer commuter belts, raising concerns regarding exurban sprawl. The increase can be almost entirely attributed to transportation-related emissions. The results stress the importance of energy use information collected at a household level to inform policy and planning decisions to reduce greenhouse gas emissions at a city level.

While where we live may be important, other factors influence direct GHG emissions. The results of the current study using household level energy use information confirm considerable variability in household GHG emissions across HRM, but also significant predictability between urban–rural zones. Other factors such as income, household size, and respondent age may be better predictors of GHG emissions (Wilson et al., in press), and are interrelated with zonal variations. Research supporting a more nuanced understanding of household GHG emissions within cities, targeting the different challenges and opportunities of different zones, will benefit efforts to achieve GHG reductions.

References

Benders, R., Kok, R., Moll, H., Wiersma, G., Noorman, K., 2006. New approaches for household energy conservation—in search of personal household energy budgets and energy reduction options. Energy Policy 34, 3612–3622.

Bricka, S., 2008. Non-response challenges in GPS-based surveys. Resource Paper, Prepared for the May 2008 International Steering Committee on Travel Survey Conferences Workshop on Non-Response Challenges in GPS-based Surveys. Retrieved from: ⟨www.nustats.com/nustats_dot_com/templates/yet again_new-menu/docs/great_reads/Nonresponse_GPS_BasedSurveys.pdf⟩.

Davis, J.S., Nelson, A.C., Dueker, K.J., 1994. The new 'burbs'. The exurbs and their implications for planning policy. Journal of the American Planning Association 60, 45–59.

Druckman, A., Jackson, T., 2008. Household energy consumption in the UK: a highly geographically and socio-economically disaggregated model. Energy Policy 36, 3177–3192.

Environment Canada, 2010. National Inventory Report 1990–2008: Greenhouse Gas Sources and Sinks in Canada. ISBN: 978-1-100-15579-1. Cat. No.: En81-4/2008E-PDF, Ottawa, ON.

Ewing, R., Cervero, R., 2010. Travel and the built environment: a meta-analysis. Journal of the American Planning Association 76, 265–294.

Haq, G., Owen, A., 2009. Green streets, the neighbourhood carbon footprint of York. Stockholm Environment Institute, Stockholm.

Hoornweg, D., Sugar, L., Gomez, C., Lorena Trejos, 2011. Cities and greenhouse gas emissions: moving forward. Environment and Urbanization 23, 207–227.

Kang, H., Scott, D., 2010. Exploring day-to-day variability in time use for household members. Transportation Research Part A 44, 609–619.

Kok, R., Benders, R., Moll, H., 2006. Measuring the environmental load of household consumption using some methods based on input–output energy analysis: a comparison of methods and a discussion of results. Energy Policy 34, 2744–2761.

Lamb, R., 1983. The extent and form of exurban sprawl. Growth & Change 14, 40–47.

Lenzen, M., Dey, Christopher., Foran, B., 2004. Energy requirements of Sydney households. Ecological Economics 49, 375–399.

Millward, H., 2006. Metropolitan Form and the Environment. In: Bunting, T., Fillion, P. (Eds.), Cities in Transition, 3rd ed. Don Mills, Oxford, UK, Canadian, pp. 363–378.

Millward, H., Spinney, J., 2011a. Time use, travel behavior, and the rural-urban continuum: results from the Halifax STAR project. Journal of Transport Geography 19, 51–58.

Millward, H., Spinney, J., 2011b. "Active Living" related to the rural-urban continuum: a time-use perspective. Journal of Rural Health 27, 141–150.

Moll, H., Noorman, K., Kok, R., Engström, R., Throne-Holst, H., Clark, C., 2005. Pursuing more sustainable consumption by analyzing household metabolism in European countries and cities. Journal of Industrial Ecology 9, 259–278.

Nansai, K., Inaba, R., Kagawa, S., Moriguchi, Y., 2008. Identifying common features among household consumption patterns optimized to minimize specific environmental burdens. Journal of Cleaner Production 16, 538–548.

Natural Resources Canada (NRCAN), 2010. 2007 Survey of Household Energy Use, Office of Energy Efficiency.

Nelson, A., 1991. Toward a definition of exurbia. Journal of Planning Literature 6, 350–368.

Our HRM Alliance, 2012. Our Seven Solutions, Planning for Liveable Communities, 2nd edition, HRM Alliance ⟨http://www.ourhrmalliance.ca⟩.

Parshall, L., Gurney, K., Hammer, S., Mendoza, D, Zhou, Y., Geethakumar, S., 2010. Modeling energy consumption and CO2 emissions at the urban scale: Methodological challenges and insights from the United States. Energy Policy 38, 4765–4782.

Spinney, J., Millward, H., 2011. Weather impacts on leisure activities in Halifax, Nova Scotia. International Journal of Biometeorology 55, 133–145.

Statistics Canada, 2006. General Social Survey—Cycle 19: time use (2005) user's guide to the public use microdata file, Ottawa, ON.

Statistics Canada, 2012. 2011 Census, Population and dwelling counts. Catalogue number 98-310-XWE2011002, Ottawa, ON.

Taylor, L., 2011. No boundaries: exurbia and the study of contemporary urban dispersion. GeoJournal 76, 323–339.

Time Use Research Program (TURP), 2008. Halifax Regional Space Time Activity Research (STAR) survey: sampling strategy, Saint Mary's University, Time Use Research Program, Halifax, NS.

Time Use Research Program (TURP), 2010a. Halifax Regional Space Time Activity Research (STAR) survey: survey methods. Saint Mary's University, Time Use Research Program, Halifax, NS.

Time Use Research Program (TURP), 2010b. Halifax Regional Space Time Activity Research (STAR) survey: data users' guide, Saint Mary's University, Time Use Research Program, Halifax, NS.

VandeWeghe, J., Kennedy, C., 2007. A spatial analysis of residential greenhouse gas emissions in the Toronto census metropolitan area. Journal of Industrial Ecology 11, 133–144.

Weber, C., Matthews, H., 2008. Quantifying the global and distributional aspects of American household environmental impact. Ecological Economics 66, 379–391.

Weisz, H., Steinberger, J., 2010. Reducing energy and material flows in cities. Current Opinion in Environmental Sustainability 2, 1–8.

Wilson, J., Grant, J., 2009. Calculating ecological footprints at the municipal level: what is a reasonable approach for Canada? Local Environment 14, 963–979.

Wilson, J., Spinney, J., Tyedmers, P., 2013. An exploration of the relationship between socio-economic and wellbeing variables and household greenhouse gas emissions. Journal of Industrial Ecology, http://dx.doi.org/10.1111/jiec.12507.

Wilson, J., Tyedmers, P., Grant, J., 2013. Measuring environmental impact at the neighbourhood level. Journal of Environmental Planning and Management 56, 42–60.

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REVISED SUBMISSIONS

Some general guidance about writing for *Energy Policy*

Energy Policy is a multidisciplinary journal that focuses on policy issues involving energy supply and use, and it has a multidisciplinary readership that includes academics, policymakers and policy analysts. Writing for all these audiences simultaneously demands much from our authors and the editorial process.

The ideal Full-Length Article or Research Note would contain original research and be built around the policy issue on which it intends to shed light. The title should convey the policy relevance of the work rather than the technical content.The abstract also should contain at least one statement about the policy content.

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Although Energy Policy does not have mandatory structure, authors may want to consider the following structure as a point of departure:

1. Introduction
2. Methodology and Data
3. Results and Discussion
4. Conclusion and Policy Implications

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CLARK COUNTY COMPREHENSIVE PLAN 2016 UPDATE
PLANNING FOR GROWTH 2015 – 2035

Clark County Agriculture and Forest Land Supplemental Mapping and Data Analysis – Issue Paper 9

EXECUTIVE SUMMARY

The Clark County Board of County Councilors (BOCC) has developed a preferred alternative for the Comprehensive Plan Update 2016. Within the Preferred Alternative are proposals to modify the minimum lot size of the current AG 20 zone to allow 10-acre lots and an amended zone district of AG 10. Similarly the current Forest 40 would be altered to allow 20-acre lot sizes and an amended zone district of Forest 20.

This Issue Paper 9 examines agricultural and forest land two parts:

I. Agriculture and Forest Land Supplemental Mapping and Data Analysis

II. Literature Review and Example Counties Providing Regulatory Support for Producers

Part I includes supplemental mapping and data analysis addressing new information unavailable at the time of the 2012 Rural Lands Study. Part II also updates the status of rural and resource conservation tools examined in the 2012 study as well as includes a brief literature review regarding urban agriculture trends.

Generally findings show:

- Clark County's numbers of farms declined between 2007 and 2012, but there is still an overall increase since 1997.
- Clark County's median farm size declined between 2007 and 2012. Clark County's median farm size is comparable to other urbanized counties like Pierce, King, and Snohomish.
- The vast majority of farmers live on farm, and likewise most farms are family owned.
- Most AG zoned land contains residences, as does Forest Tier II land.
- The median AG zoned parcel size is 5.1 acres. About two-thirds of AG zoned parcels are equal to or less than 10 acres in size. Farming can and has been occurring on smaller parcels as part of serving an urban market with local food (see discussion of small farms below). Clustering and siting criteria for new buildings could help orient buildings away from productive soils.
- Parcels proposed for Forest 20 zoning are similarly matched to the zone lot size: 89% are less than or equal to 20 acres in size. State rules and programs recognize the value of small forest owners and have programs for owners of 10 or 20 acres in size. Current use criteria allow parcels of a minimum of five acres to apply for a current use tax reduction.

- The County continues to have a uniquely high proportion of very small farms (producing values of commodities at $10,000 or less) that appear to support a local food market. The County has among the highest of farms with direct sales to consumers in the state.

- Most of the urban counties in Washington have implemented a variety of tools to protect both the farmland and farmer by allowing residential uses, while applying lot standards that promote the protection of agricultural activities and prime soils. Urban counties have similar tools for forestland.

I. AGRICULTURE AND FOREST LAND SUPPLEMENTAL MAPPING AND DATA ANALYSIS

1.0 PURPOSE AND BACKGROUND

The Clark County Board of County Councilors (BOCC) has developed a preferred alternative for the Comprehensive Plan Update 2016. Within the Preferred Alternative are proposals to modify the minimum lot size of the current AG 20 zone to allow 10-acre lots and an amended zone district of AG 10. Similarly the current Forest 40 would be altered to allow 20-acre lot sizes and an amended zone district of Forest 20.

A Rural Lands Study (BERK Consulting et al. 2012) provided a market assessment of agriculture and forestry in Clark County. It identified the following findings:

> *Key Finding #1: Agriculture in Clark County in 2011 is in the midst of a decade's long transition from large scale commodity farming into more intensive, value-added, urban-oriented farming.*
>
> *Key Finding #2: Large farm and mid-size farms are declining in number, acres, and value. However, they remain a viable enterprise but face a multitude of challenges.*
>
> *Key Finding #3: A Diverse set of small farms and enterprises are increasingly becoming part of the rural landscape.*
>
> *Key Finding #4: Timber production is diminished, but retains a productive and uncertain presence in the County.*

With the Comprehensive Plan Update, Clark County has examined the amended AG 10 and FR 20 districts and has considered potential clustering or building envelope criteria. The BOCC is considering the application of the new districts without clustering, but potentially with building envelope criteria.

This document provides supplemental mapping and data analysis to address new information unavailable at the time of the 2012 Rural Lands Study, particularly:

- Census of Agriculture 2012: Though the Rural Lands Study was conducted in 2012, the Census of Agriculture was conducting its latest census at the same time and results were not available; only 2007 Census information was available. The trends in terms of farm size, commodity value, and operation characteristics can be assessed with 2012 Census results to determine if the above findings are still accurate.

- Washington State Department of Agriculture Crop Type: In 2012, the State provided crop information at the section level. Now information at the field level is available and can be included with AG 10 parcel information.

- The current parcel size pattern underlying the Forest 40 zone was mapped but not quantified. Given a proposed Forest 20 zone, the lot size pattern is addressed in this supplemental analysis.

2.0 AGRICULTURE AND FOREST LAND MAPPING AND DATA ANALYSIS

This section presents information considered in the 2012 Rural Lands Study and updated with 2012 Census of Agriculture information. An overview of the new information is presented followed by findings and supporting data.

2.1 Changes in Farm Numbers and Type based on Value of Commodities

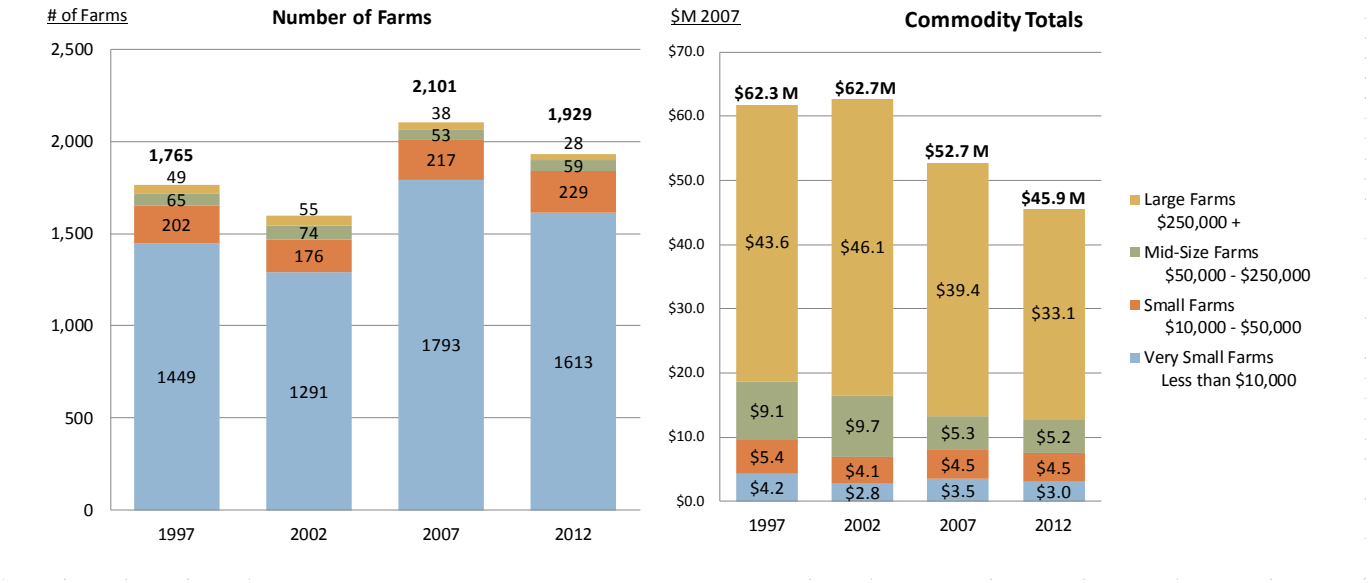
One of the findings in the 2012 Rural Lands Study was a trend away from large scale commodity farming into more intensive, value-added, urban-oriented farming, evidenced by declines in large and mid-size farms by number, acres, and value. This was based on a review of federal and state data, particularly the 1997, 2002, and 2007 Census of Agriculture data. 2012 information is now added in this section.

NUMBER OF FARMS: The 2007 Census of Agriculture found a total of 2,101 farms in Clark County. This represents an increase from the 2002 Census of 1,596 farms, as well as from the 1997 Census, which counted 1,765 farms in Clark County. The number of farms equals 1,929 in 2012. This represents a decrease of 172 farms since 2007. Countywide there are still more farms in 2012 than reported in the 1997 and 2002 Census counts. Thus the overall trend of an increase since 1997 or 2002 is still valid in the year 2012.

FARM SIZE BY VALUE OF COMMODITIES: Exhibit A presents agriculture in Clark County in four segments according to commodity totals: large farms (less than $250,000), mid-size farms ($50,000-$250,000), small farms ($10,000-$50,000) and very small farms (less than $10,000).[1]

[1] The first three categories would fall under the definition of "small" farms by the National Commission on Small Farms of all farms with sales less than $250,000. This definition would miss much of the agricultural activity in Clark County. The USDA Economic Research Service has categorized farms under $50,000 as non-commercial – meaning farming is not their primary income – but the USDA National Commission on Small Farms (1998) notes "this categorization fails to recognize that for some of these farmers, off-farm jobs are not a choice, but a necessity due to the inability to obtain an adequate return from farming" and that "when a gross sales statistic is used combining all agricultural sectors, it can generate the conclusion that large and super-large farms produce most of the food and fiber in this country, when, in fact, the most critical production occurs at the primary level." Thus, in this Issue Paper farms are described in a range of small, very small, mid-sized, and large based on value. This size range does not imply that very small or small lands are not of long-term commercial significance, which is a Growth Management Act definition.

Exhibit A. Clark County Farms Size by Value of Commodities (2007$) (RLS Exhibit 5)



*"Farms" only include farms having, or usually having, sales of $1,000 or more in a year. Commodity totals normalized to 2007 dollars using CPI.
Since the 2012 Rural Lands Study, the graph has been updated to include 2012 Census of Agriculture data unavailable at the time of the Rural Lands Study preparation. The value of commodities by farm type segment reported in the 2012 Rural Lands Study for the years 1997, 2002, and 2007 are unchanged; however the total of all farm types at the top of the bars has been corrected.

Source: U.S. Census of Agriculture, National Agricultural Statistical Service; BERK, 2012 and 2016.

Some key findings of farm activity in Clark County include:

- **The number of farms has increased between 1997 and 2012, though dipping slightly between 2007 and 2012.**
    - Clark County had 2,101 farms in 2007, representing the addition of 336 farms since 1997. The number of farms decreased to 1,929 in 2012, a decrease of 172 farms since 2007. The 2012 count is still higher than 1997 which counted 1,765 farms and than 2002 which counted 1,596 farms.
    - Based on values of commodities, between 1997 and 2007, the growth in the number of farms was mostly in very small farms with a slight increase in small farms, though some of the increase may be attributed to increased efforts of the USDA to count all small farms in the census.
    - Based on value, between 1997 and 2012 the overall pattern shows an increase in very small farms from 1,449 to 1,613.
        - Between 2007 and 2012, there was a loss of very small farms from 1,793 to 1,613 (-180), and a slight increase in small farms from 217 to 229 (+12).
        - On the whole the 2007 results showed 96% of farms were very small or small and similarly in 2012, 95% of farms are small or very small based on value of commodity sales.

- **Large farms are declining.**
    - Large and mid-sized farms both decreased between 1997 and 2007. These two categories represent only 4% of all farms in Clark County in 2007.
    - Between 1997 and 2007, Clark County lost 23 farms that produced over $50,000 in commodities, an average of two mid-sized and/or large farms per year.
    - Between 1997 and 2012, Clark County lost 27 farms that produced over $50,000 in commodities, almost two mid-sized and/or large farms per year.
        - Between 2007 and 2012 there was a slight increase in mid-sized farms from 53 to 59 (+7) and a loss of large farms from 38 to 28 (-10).
    - While the number of large farms has decreased between 1997 and 2012, mid-sized and large farms' share of total commodity output stayed nearly constant:
        - 1997: 85%
        - 2002: 89%
        - 2007: 85%
        - 2012: 84%
- **Commodity values are declining.**
    - Commercial farms are the most productive farm type, with 38 farms producing $39.4 Million as of 2007. Put another way, 3% of Clark County farms accounted for 75% of total commodity outputs.
    - Per 2012 results, 1.5% of the farms are large, representing 72% of the total commodity outputs.
    - The loss of large farms corresponds to a loss in commodity totals. In 2007 dollars, the value of agriculture dropped from $62.3 million in 1997 to $52.7 million in 2007, and again to $45.9 million in 2012.

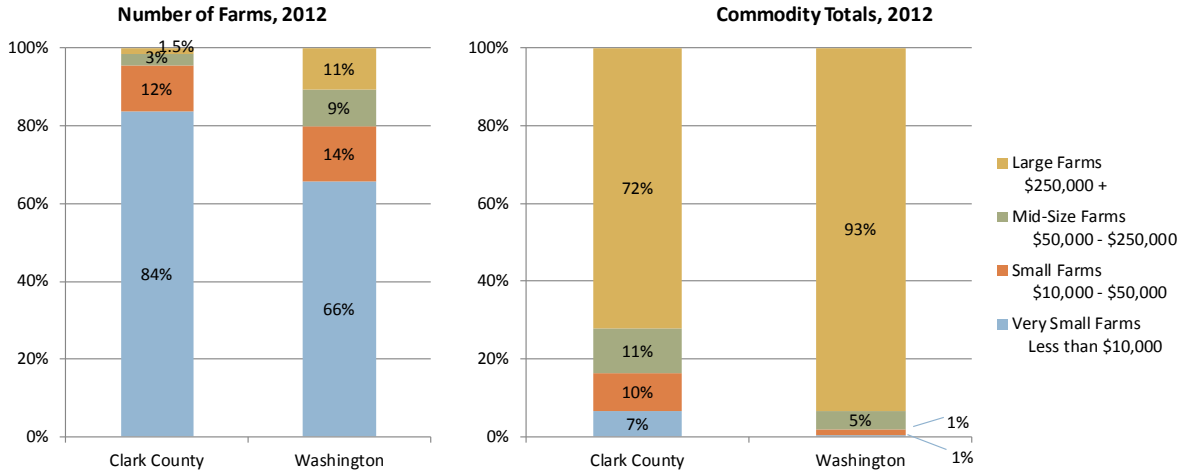
2.2 Trends and Shares in Commodities Values and Acreage

TRENDS IN COMMODITY TOTALS: Commodity totals provide the best measure of farms in terms of economic activity, and trends are examined below. The 2012 Rural Lands Study found that Clark County's prevalence of very small farms producing less than $10,000 in value of commodities is fairly unique in Washington. The 2012 study found Clark County to have the highest proportion of such very small farms in 2007in the state; now, Clark County is the second highest as of 2012, only behind Pend Oreille County. Nevertheless, in Western Washington, Clark County has the highest number of farms that are very small as of 2012.

In terms of mid-size farms and large farms, the 2012 Rural Lands Study found they produce the vast majority of commodity values in the county with relatively few farms considering 2007 data. That finding is still true as of the 2012 Census. See Exhibit B. However, there are fewer large farms than in

2007 and the overall commodity values are lower in 2012 than in prior years (values all adjusted to 2007$).

Exhibit B. Percentage of Farms by Commodity Total (2007$) (RLS Exhibit 7)



Source: U.S. Census of Agriculture, National Agricultural Statistical Service; BERK, 2016.

- Clark County's has the second highest proportion of farms that are "very small" in Washington State only behind Pend Oreille County.
    - Approximately 84% of Clark County farms earn less than $10,000 a year, compared to only 66% statewide. Only 4% of Clark County farms earn more than $50,000 a year, while almost 20% of Washington farms earn at least $50,000.
    - Grouping large and mid-size farms together, 4% of Clark County's farms account for 84% of commodity totals, compared with 20% of Washington farms accounting for 98% of commodity totals. Clark County's very small farms account for a total of 7% of commodity totals while Washington's 66% account for less than 1%.
- Though large farms account for a very small share of total farms, they represent a largest share of commodity totals.
    - In 2012, large farms only accounted for 1.5% of all farms in Clark County but 72% of all commodity totals.
    - In 2012, mid-size and large farms produced $38.4 million in commodities, representing 84% of farm production in the County.

SHARE OF FARMS BY ACRE SIZE: In addition to most farms in Clark County (84%) having commodity totals of less than $10,000, many farms in Clark County are on small acreage. This has become more pronounced in the 2012 Census of Agriculture after the publication of the 2012 Rural Lands Study.

As of the 2012 Census the share of farms sized 1-9 acres has reached 44%, 10% greater than the 34% share observed in 2007. Conversely there has been a decrease in the share of farms sized 10-50 acres, now at 42% of farms rather than the 50% share observed in 2007.

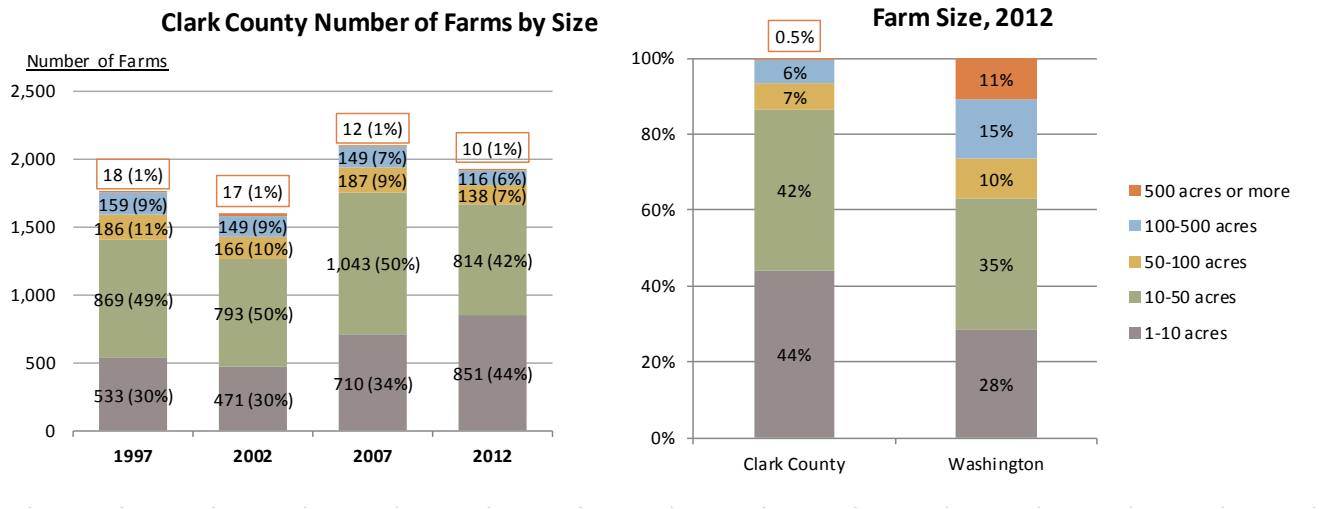
In 2007 the median size of a Clark County farm was 15 acres, compared to the Washington median of 30 acres. In 2012, the median size of a Clark County farm dropped to 10 acres while Washington State's numbers also dropped to 24 acres.

Similar to findings in the 2012 Rural Lands Study Clark County continues to have a greater proportion of small farms compared to Washington State.

The 2012 Census data continue to show a trend towards smaller, urban farms rather than mid-size and larger large farms.

Exhibit C presents the number and percent of farms by number of acres.

Exhibit C. Percent of Farms by Acres (RLS Exhibit 8)



*Land in farms is based on the number of acres reported by farm operators and includes both owned and leased lands. Total farm land for an operation may not be contiguous.

Source: U.S. Census of Agriculture, National Agricultural Statistical Service; BERK, 2012.

- **Clark County farms tend to be small in terms of acres.**
  - Between 1997 and 2007 the percentage of small farms increased by 4%. The percentage of small farms grew by 14% between 1997 and 2012.
    - The most significant change occurred since 2007, where there has been an increase in the percentage of farms sized 1-9 acres, at 44%, an increase of 10% by 2012.
  - About 42% of Clark County farms are between 10 and 50 acres as of 2012, a decrease since 2007 at 50%.
  - There has been a decrease in farms greater than 50 acres between 1997 and 2012.

- Growth in farms has been in the lower scale of acres (10 acres or smaller), while larger farms have declined between 1997 and 2012.

- **Clark County has a greater proportion of small farms compared to Washington State.**
  - Clark County has a greater proportion of farms smaller than 50 acres (86%) than Washington (63%), and many fewer farms larger than 500 acres (less than 1%) than Washington (11%).
  - Between 1997 and 2007, the number of Clark County farms with between 50 and 500 acres stayed relatively constant, with a difference of only nine less farms. However, between 2007 and 2012, the number of large farms decreased by 82 to 254.

- **Farm size reflects urban and suburban land use patterns with agriculture dominated by small-scale operations.**
  - The average size of a Clark County farm in 2007 was 37 acres, compared to the Washington average of 381 acres. The Clark County farm average in 2012 was slightly higher at 39 acres as was the average for Washington State at 396 acres.
  - In 2007 the median size of a Clark County farm was 15 acres, compared to the Washington median of 30 acres. In 2012, the median size of a Clark County farm dropped to 10 acres while Washington State's numbers also dropped to 24 acres. Clark County's numbers are comparable to other, primarily urban counties like Pierce (10) and King (8).
  - Both Clark County and Washington farms have experienced declines in farm size since 2002. Clark County's average farm size was 44 acres in 2002 and now is 39 acres as of 2012. Washington's average farm size was 426 acres in 2002, and now is 396 acres.

CROP TYPES AND COMMODITY TOTALS: Based on either 2007 or 2012 data, the type of commodities prevalent in the County continues to include cattle, crops and hay, poultry and eggs, fruit and tree nuts. As of 2012, vegetables and melons have increased their share of crop types. See Exhibit D, part 1.

As of 2012 there has been a marked drop in commodity values to $45.9 million compared to $52.6 million in 2007 (all in 2007$). This continues a decline in commodities values since 1997 at $62.2 million (similar to 2002 figures). See Exhibit D, part 2 and part 3.

Considering either 2007 or 2012 information, milk and dairy products continue to have the greatest share of commodity values though the number of dairies has dropped from 25 to 9 in that same time frame. Poultry and eggs are another animal product with a significant share of the commodity value in both periods. However, cattle values have increased by 2012.

Exhibit D. Crops by Clark County Farms and Commodity Totals (RLS Exhibit 9)

1. Number of Farms by Commodity Type

	Number of Farms							
Agricultural Products	**1997**	**2002**	**2007**	**2012**	**Percentage Change 2002 and 2007**	**2007 Percentage of Total**	**Percentage Change 2007 and 2012**	**2012 Percentage of Total**
Cattle and calves	838	502	547	476	-35%	24%	-13%	23%
Crops and hay	-	284	429	368	51%	19%	-14%	18%
Poultry and eggs	113	120	309	260	173%	14%	-16%	13%
Fruit, tree nuts, and berries	103	117	215	217	109%	9%	1%	11%
Horses, ponies, mules, burros, and donkeys	-	142	167	112	18%	7%	-33%	5%
Sheep, goats, and their products	-	105	153	108	46%	7%	-29%	5%
Cut Christmas trees and short term woody crops	-	46	69	58	50%	3%	-16%	3%
Hogs and pigs	38	49	62	68	63%	3%	10%	3%
Milk and other dairy products from cows	32	25	25	9	-22%	1%	-64%	0%
Grains, oilseeds, dry beans, and dry peas	-	17	15	25	-12%	1%	67%	1%
Aquaculture	-	4	7	2	75%	0%	-71%	0%
Other animals and animal products (specialty animal)	-	55	83	72	51%	4%	-13%	3%
Vegetables, melons, potatoes, sweet potatoes	-	45	104	176	131%	5%	69%	9%
Nurseries, greenhouse, floriculture, and sod	-	140	98	107	-30%	4%	9%	5%
Total Farms with Sales - Specified Products	1,124	1,651	2,283	2,058	38%		-10%	
Total Farms with Sales Not Specified	1,765	1,596	2,101	1,929	32%		-8%	

Notes Table 9.A:

Sources are the 2002, 2007, and 2012 Census of Agriculture which compares new year to prior year totals. Thus, 2002 Census compared 2002 and 1997 Census totals, and the 2007 Census compared 2007 and 2002 totals. Red Text – The 2012 Census comparing 2012 and 2007 indicated "not available" for these categories in 2007 even though they were reported in the 2007 Census. 2007 Census information is retained.

The total farms with sales of specified products may exceed total farms with sales, not specified, because farms may sell more than one product. Anomalies in 1997 may be expected as this is the first year USDA took over the Census of Agriculture. (Wendy Vance, USDA, Olympia, May 23, 2012).

Reviewing the 1997 Census, the categories were differently titled and led to "not available" or "-" information when 1997 information was reported in the 2002 Census. The total farms with sales in 1997 was originally reported as 1,175, whereas in the 2002 Census the number of farms in 1997 was reported as 1,765

Data is sorted by 2007 number of farms, highest to lowest. In 2012, the order is generally the same except that "vegetables, melons, potatoes, sweet potatoes" appeared to increase above "sheep, goals, and their products."

2. Commodity Type and Totals in 2007 Dollars

	Commodity Totals (in 2007 $)							
Agricultural Products	**1997**	**2002**	**2007**	**2012**	**Percentage Change***	**2007 Percentage**	**Percentage Change 2007 and**	**2012 Percentage**
Milk and other dairy products from cows	$ 18,384,324	$ 10,965,268	$ 11,841,000	$ 13,117,253	-36%	22%	11%	29%
Poultry and eggs	$ 7,729,141	$ 8,103,511	$ 10,640,000	$ 7,020,552	38%	20%	-34%	15%
Fruit, tree nuts, and berries	$ 5,367,639	$ 6,680,124	$ 9,858,000	$ 6,175,269	84%	19%	-37%	13%
Cattle and calves	$ 7,069,006	$ 5,437,685	$ 5,439,000	$ 7,226,455	-23%	10%	33%	16%
Cut Christmas trees and short term woody crops	$ -	$ 1,509,828	$ 2,976,000	$ -	97%	6%	0%	0%
Other crops and hay	$ -	$ 1,762,234	$ 1,798,000	$ 2,469,927	2%	3%	37%	5%
Horses, ponies, mules, burros, and donkeys	$ -	$ 647,728	$ 917,000	$ 676,408	42%	2%	-26%	1%
Grains, oilseeds, dry beans, and dry peas	$ -	$ 212,067	$ 450,000	$ 441,607	112%	1%	-2%	1%
Sheep, goats, and their products	$ -	$ 291,593	$ 342,000	$ 97,533	17%	1%	-71%	0%
Hogs and pigs	$ 117,558	$ 81,830	$ 37,000	$ -	-69%	0.1%	0%	0%
Other crops	$ 23,586,606	$ 27,016,697	$ 8,393,000	$ 8,707,507.88		16%	4%	19%
Total	$ 62,254,274	$ 62,708,565	$ 52,691,000	$ 45,932,510	-15%	100%	-13%	100%

Notes Table 9B: .Legend "-" = not available. 2002 value for horses adjusted to 2007 dollars to match approach to rest of values.
Source: U.S. Census of Agriculture, National Agricultural Statistical Service; BERK, 2012 and 2016.

3. Commodity Type and Totals in 2007 Dollars

	Commodity Value per Farm (in 2007 $)					
Agricultural Products	**1997**	**2002**	**2007**	**2012**	**Percentage Change 1997-2007***	**Percentage Change 2002-2012**
Milk and other dairy products from cows	$ 574,510	$ 438,611	$ 473,640	$ 1,457,473	-18%	232%
Poultry and eggs	$ 68,399	$ 67,529	$ 34,433.66	$ 27,002	-50%	-60%
Fruit, tree nuts, and berries	$ 52,113	$ 57,095	$ 45,851	$ 28,457	-12%	-50%
Cattle and calves	$ 8,436	$ 10,832	$ 9,943	$ 15,182	18%	40%
Cut Christmas trees and short term woody crops	$ -	$ 32,822	$ 43,130	$ -	31%	0%
Other crops and hay	$ -	$ 6,205	$ 4,191	$ 6,712	-32%	60%
Horses, ponies, mules, burros, and donkeys	$ -	$ 4,561	$ 5,491	$ 6,039	20%	10%
Grains, oilseeds, dry beans, and dry peas	$ -	$ 12,475	$ 30,000	$ 17,664	140%	-41%
Sheep, goats, and their products	$ -	$ 2,777	$ 2,235	$ 903	-20%	-60%
Hogs and pigs	$ 3,094	$ 1,670	$ 597	$ -	-64%	0%
Total	$ 35,271.54	$ 39,291.08	$ 25,079.01	$ 23,811.57	-29%	-39%

Notes Table 9.C:*Percentage change is between 2002 and 2007 when there is no 1997 data. Legend "-" = not available.
Source: U.S. Census of Agriculture, National Agricultural Statistical Service; BERK, 2012 and 2016.

- **Many Clark County farms have livestock of some sort.**
    - Cattle and calves are the agricultural product found on the largest number of Clark County farms. 23% of Clark County farms produce cattle and calves.
    - The number of farms with Poultry and egg products more than doubled between 1997-2007. Though it has dropped by 49 farms, in 2012 it was still more than twice the 1997 or 2002 total.
- **Fruit, tree nuts, and berries and cut Christmas trees make up the largest non-livestock portion of Clark County farms.**
    - The number of Clark County farms growing fruit, tree nut, and berry products has doubled since 1997.The number of farms growing cut Christmas trees and short term woody crops has grown by 26%.
- **Milk products make up the greatest commodity totals of Clark County farms.**
    - Despite making up only 1% of Clark County's farms, farms that produce milk and other dairy products from cows brought in almost $13.1 million, or 29% of 2012 commodity totals (in 2007$) .
    - The total is down substantially from 1997, though there were 23 additional farms producing milk in 1997. The commodity total figure has grown slightly from 2002 though there are now fewer farms.
- **Other livestock-related products (cattle and calves and poultry and eggs) brought in approximately 31% of Clark County's commodity totals in 2012.**
    - Poultry and eggs contributed $7 million in value in 2012 (in 2007 dollars), or 15% of 2012 commodity totals (and make up only 13% of farms). Similarly cattle and calves are at just over $7.2 million (in 2007 dollars), or 13% of 2012 commodity totals (making up 23% of Clark County farms).
- **Fruit, tree nuts, and berries contribute 13% of commodity totals despite only representing 11% of farms.**

2.3 Farm Composition and Tenure

The Census of Agriculture provides information about the composition of farms – family versus corporate owned, as well as demographic characteristics such as age, sex, and income sources.

- There is a continuing trend of farms being family owned – over 90% in both 2007 and 2012. There is a very small percentage that are corporate owned in either period. See Exhibit E.
- Reflecting a family-operated trend in farming, a high proportion of farmers live on farm at about 90% in either 2007 or 2012.

- There is a greater reliance of farmers to have non-farm jobs. Though about one-third solely rely on their on farm income in both 2007 and 2012 periods, about 48% of farmers worked more than 100 days off farm in 2007, rising to 52% in 2012.

- The proportion of farmers over 55 years of age has increased from more than half to two-thirds between 2007 and 2012.

Exhibit E. 2007 and 2012 Farm Typology (RLS Exhibit 13)

	2007				2012			
Type of Farm	Farms	Percent	Acres	Percent	Farms	Percent	Acres	Percent
Land in Farms	2,101	100%	78,359	100%	1,929	100%	74,758	100%
Family or individual	1,896	90%	67,185	86%	1,678	87%	60,254	81%
Partnership	107	5%	6,668	9%	117	6%	8,191	11%
Corporation \ Family-held	70	3%	3,022	4%	71	4%	2,966	4%
Corporation \ Other than family held	3	0.1%	-	-	9	0%	917	1%
Other - cooperative, estate or trust, institutional, etc.	25	1%	-	-	54	3%	2,430	3%

Source: U.S. Census of Agriculture, National Agricultural Statistical Service; BERK, 2012.

- **Most farms in Clark County are family- or individual-owned.**
    - Approximately 93% of Clark County farms are family farms (e.g. owned by families, individuals, or family-held farm corporations). In 2012, only nine farms were owned by non-family-held corporations.

- **Most operators have their place of residence on farm:**
    - 2007: 89%
    - 2012: 90%

- **Farm operators tend to be older.**
    - As of 2007, more than half of farm proprietors are 55 years or older (1,136 farms, 54%), with 18% (377 farm operators) being older than 70 in 2007. Only 4% (85 operators) of farm operators were younger than 35 in the same year.
    - By 2012, the percentage of farm operators that were 55 years or older has risen to about two-thirds (1,261, 65%). About 21% of operators are 70 years or older (404 farms), while 4% of farmers were less than 35 years old (78 farms).

- **Clark County farmers typically have off-farm jobs.**
    - That farmers tend to have non-farm occupations as their primary has been fairly consistent since 1997. In 1997, 67% of Clark County farmers had a non-farm primary occupation. In 2007, 61% of farmers had a primary occupation other than farming while 65% of farmers have a non-farm primary occupation as of 2012.

- Only 32% of Clark County farmers did not work any days off their farm in 2007 rising slightly to 35% by 2012. Those working up to 99 days off-farm included 19% in 2007 falling to 13% in 2012. 48% of farmers worked more than 100 days off farm in 2007, rising to 52% in 2012.

- In 2012, Statewide, 47% of farmers are principally engaged in farming, which is slightly higher than 46% in 2007.

- **Farmers tend to be male, though the number and percentage of female farm operators is growing.**

  - In 2007 and 2012, about 23% of all farm operators were female. The number of female farm operators has increased 75% between 1997 and 2007 while the number of male farm operators has increased 9% over the same period. By 2012, the number of either male or female operated farms dropped, but the proportion of female operators is essentially the same as 2007.

2.4 Location and Spatial Patterns of Agriculture

Both the USDA Agriculture Census and Clark County Assessor's data do not provide geospatial specific locations of the actual land being farmed and the nature of the farming. The best information about the location of farming (and type) can be gleaned from a synthesis of the Current Use Taxation Program and Washington State Department of Agriculture's (WSDAs) Crop Use data (

Exhibit F). This location-specific mapping of farm fields and crop type is new since the 2012 Rural Lands Study.

PREVALENT CROP TYPES: The Census of Agriculture 2012 reported Clark County had a total of 74,758 acres in farms. WSDA maps the extent of agriculture based on field visits and aerial photography, identifying more exact boundaries of fields and facilities that are independent of parcel lines. WSDA's detailed and local inventory dated 2015 found about 27,443 acres in agriculture in Clark County. This is similar to the 2012 Census report of total cropland at 28,986 acres.

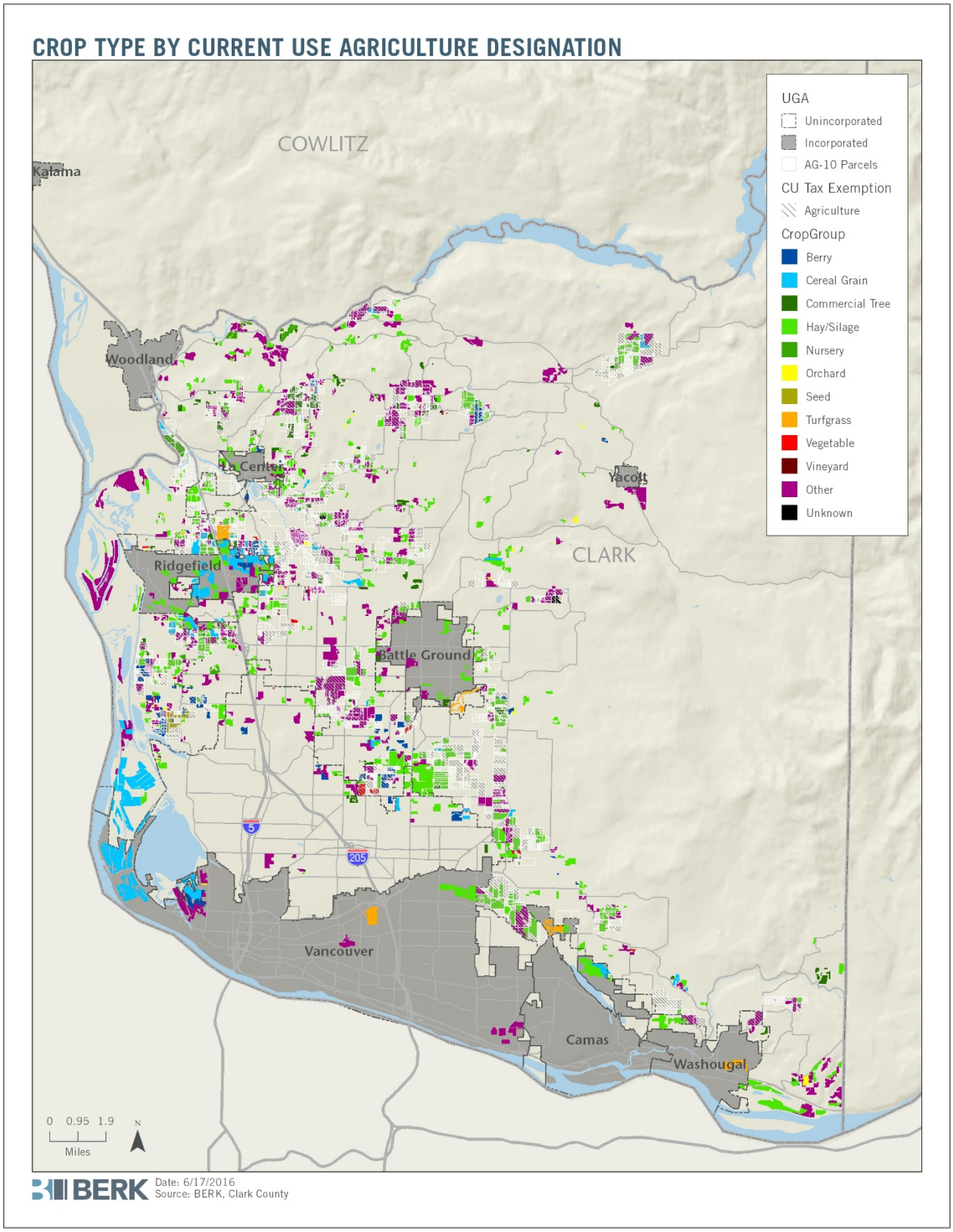
The mapped WSDA information shows hay/silage, cereal grains, and "other" (pasture, fallow, commercial trees, etc.)[2] are the predominate corps in Clark County by section acreage. Per Exhibit F, much of the land in active agricultural use is located in unincorporated areas and is zoned Rural as well as AG (currently AG 20, proposed AG 10).

This pattern of small farms being found in both the Rural and AG zoned areas is similar to findings in 2012 Rural Lands Study. That study identified the diversity in location and type of agriculture across the County, and found that a diverse set of small farms and enterprises are increasingly becoming part of the rural landscape. Per the Census of Agriculture results, very small and small farms that produce little income, are mostly supported with non-farm income. Many farmers in this category farm for non-market reasons and may be willing to farm at a loss, given unpaid farm labor within these households. The growing demand for local produce and increasing market share of CSAs presents farms in these

[2] Other includes: Pasture, Market Crops, Fallow, Silviculture, Christmas Trees, Wildlife Feed, CRP/Conservation, and Developed.

categories with opportunities to generate additional income. Many of these farms also host other co-located rural business that may, or may not, be related to agricultural production.

Exhibit F. Crop Type by Current Use Agriculture Designation (RLS Exhibit 16)



Source: BERK, 2016.

AG 10 AND WSDA AGRICULTURAL INVENTORIES: Given onsite development or other non-productive rural uses (e.g. dwellings, manicured lawns associated with dwellings, etc.) there is a greater area zoned AG and a lesser area inventoried by WSDA in agricultural use. WSDA inventoried acres make up between 15-27% of the AG 10 zone area. See Exhibit G.

Exhibit G. AG 10 Zone, State Agricultural Inventory Acres

AG Zone Parcel Size Range	Number of Parcels	Percent of Total Parcels	AG Zone Parcel Acres	Housing Units	WSDA Agriculture Inventory Acres	Percent WSDA Agricultural Inventory of Parcel Acres
<=5 Acres	1,152	44%	3,138	858	461	15%
5-10 Acres	609	23%	4,021	443	729	18%
10-20 Acres	432	16%	7,049	288	2,070	29%
20+ Acres	447	17%	17,902	284	4,890	27%
Total	**2,640**	**100%**	**32,111**	**1,873**	**8,150**	**25%**

Source: WSDA 2015, Clark County Assessor 2016, BERK Consulting 2016

PREVALENT LOT SIZES AND HOMESITES: Most AG zone parcels are less than 5 acres in size (44%). About 67% are less than 10 acres in size. There are properties in contiguous common ownership, which would contribute to effectively larger parcels than considering parcels individually. However, many of the lots in common ownership have homes, and likely house family members or may be sold individually. See Exhibit H and Exhibit J illustrating acres and contiguous ownership.

Exhibit H. Parcels Less than 20 Acres – Contiguous Ownership (RLS Policy Table 2)

Parcel Size Range	AG Zoned Parcel Count	AG Zoned Acres	WSDA Agriculture Inventory Acres	Sum of Dwelling Units	Percent of Lots with Dwelling Units
<=5	1,152	3,138	461	858	74%
-	863	2,413	315	759	88%
Contiguous	289	725	146	99	34%
10-20 Acres	432	7,049	2,070	288	67%
-	295	4,821	1,315	235	80%
Contiguous	137	2,228	755	53	39%
20+ Acres	447	17,902	4,890	284	73%
-	291	11,426	3,127	233	90%
Contiguous	156	6,476	1,762	51	27%
5-10 Acres	609	4,021	729	443	64%
-	443	2,909	444	398	80%
Contiguous	166	1,112	285	45	33%
Grand Total	**2,640**	**32,111**	**8,150**	**1,873**	**71%**

Source: Clark County GIS; BERK 2011

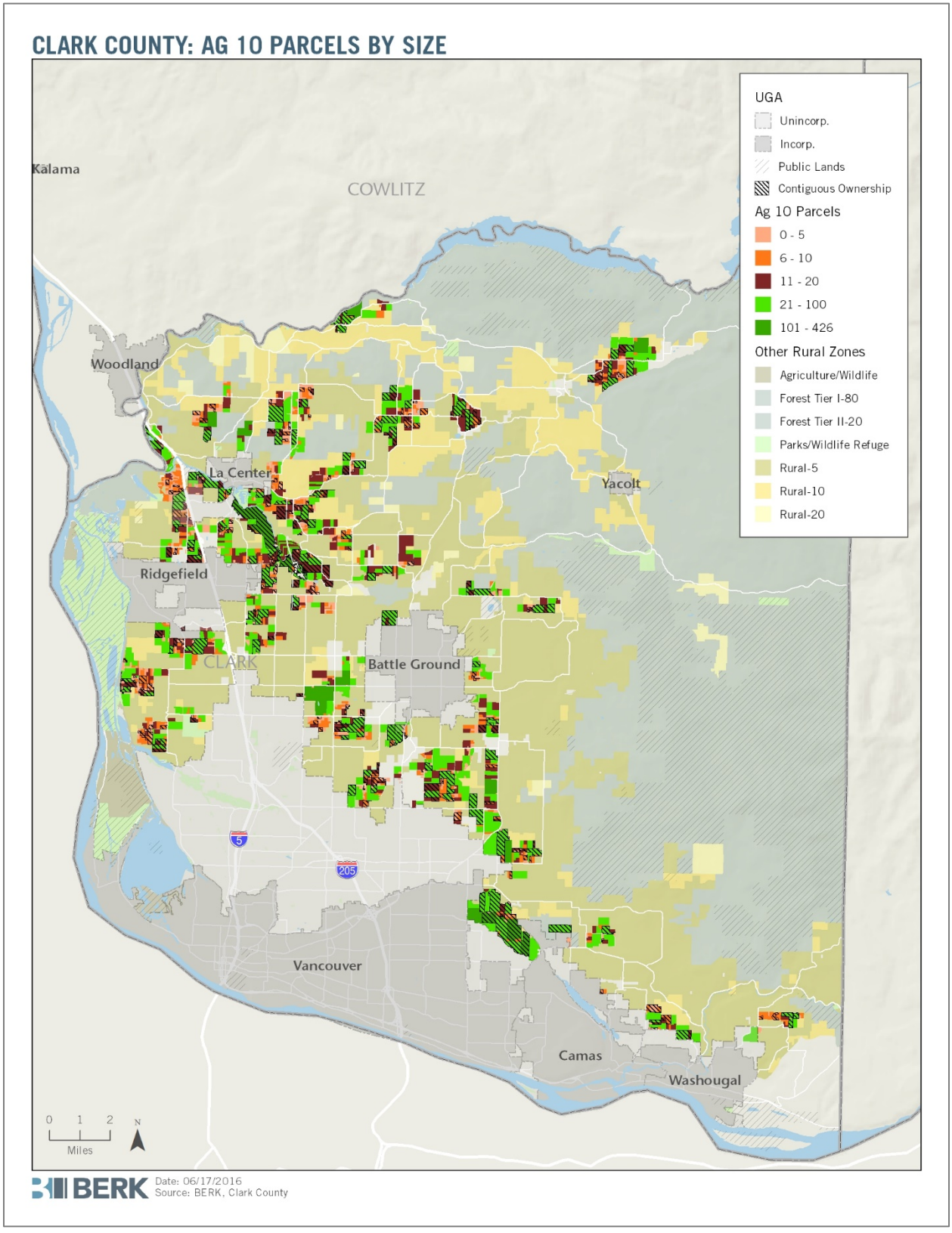
Similar to findings in the Rural Lands Study, the median parcel size in the AG zone is 5.1 acres. The median parcel size for properties in current use taxation is 18.9 acres, smaller than estimated in the Rural Lands Study, which was 21.4 acres. See Exhibit I.

Exhibit I. Median Parcel Sizes in Agriculture Zone (RLS Policy Table 1)

Size	# of Parcels	Acres	Median Parcel Size
Total Parcels/Acres	2,640	32,111	5.1
In Current Use Agriculture	819	17,002	18.9

Source: Clark County 2011

Exhibit J. AG Zone Parcel Size Map (RLS Policy Appendix B)



Source: Clark County Assessor, BERK Consulting 2016

2.5 Agricultural Criteria

Clark County designated agricultural lands of long-term commercial significance in 1994 and revisited the designations in 1998 making some adjustments of properties called Agri-forest at the time. The County's designation of AG was upheld by the Growth Management Hearings Board. The Growth Management Act provides guidelines for classification of resource lands in RCW 36.70A.050, and the Washington State Department of Commerce further defines them in Chapter 365-190 WAC. A summary of the criteria is shown in Exhibit K, along with a broad summary of conditions in the AG 10 zoned properties.

Exhibit K. Agricultural Criteria – Lands of Long-Term Commercial Significance for Agriculture

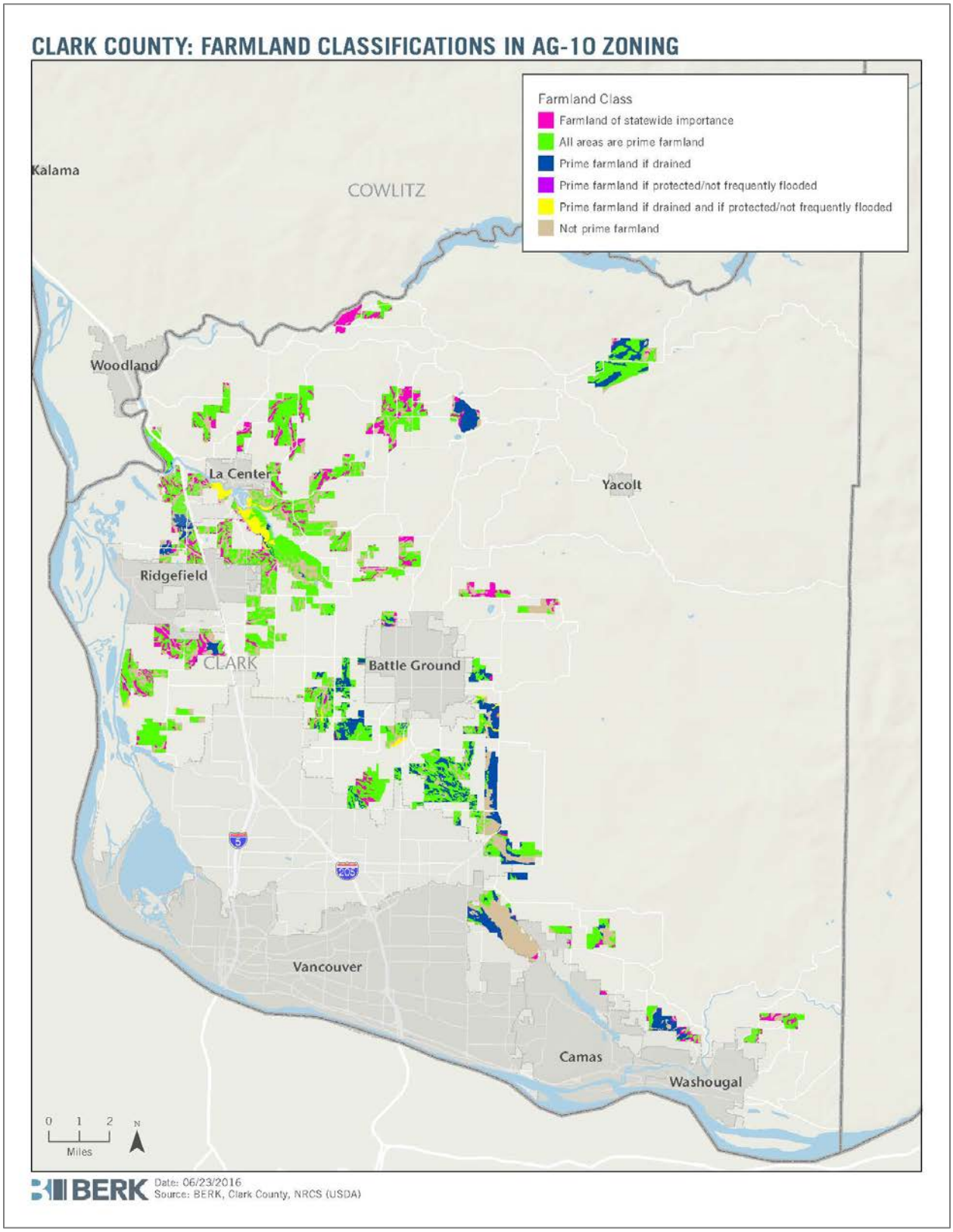
<table>
<tr><th>WAC 365-190-050 Criteria Summary</th><th>AG 10 Zone Characteristics</th></tr>
<tr><td>Areawide analysis conducted</td><td>The County conducted an areawide analysis in 1994 and 1998.</td></tr>
<tr><td>Regulations conserving agriculture adopted</td><td>Regulations allow agriculture in all zones and conserve AG designated lands.</td></tr>
<tr><td>Not already characterized by urban growth</td><td>Clark County has a prevalence of family owned farms on AG properties of 5-20 acres in size or larger. Most farmers live onsite and produce agriculture onsite based on 2012 Census of Agriculture information. The lands are not developed at an urban density.</td></tr>
<tr><td>Used or capable of being used for ag. production</td><td>Indicators of agricultural use include the WSDA inventory showing that half to a third of AG zoned sites have inventoried fields. More than half of the AG acreage is in current use taxation (see Exhibit I).</td></tr>
<tr><td>Land-capability classification</td><td>About two-thirds of the AG 10 land is in land capability classes of 1, 2, or 3. Some of the other lower capability classes are found, but are actively being farmed (e.g. Anderson dairy east of Vancouver located in floodplain). Acreages below are a little smaller than the total AG zone since it is based on parcels and exclude water or roads.
Ag-10 Zoning: Non-Irrigated Soils (Parcel Acres)
<table>
<tr><th>Non-Irrigated Soils</th><th>Acres</th><th>Percent</th></tr>
<tr><td>Non-Irrigated Class 1</td><td>2,121</td><td>7%</td></tr>
<tr><td>Non-Irrigated Class 2</td><td>6,918</td><td>22%</td></tr>
<tr><td>Non-Irrigated Class 3</td><td>10,764</td><td>35%</td></tr>
<tr><td>Non-Irrigated Class 4</td><td>1,328</td><td>4%</td></tr>
<tr><td>Non-Irrigated Class 5</td><td>242</td><td>1%</td></tr>
<tr><td>Non-Irrigated Class 6</td><td>7,833</td><td>25%</td></tr>
<tr><td>Non-Irrigated Class 7</td><td>1,388</td><td>4%</td></tr>
<tr><td>Non-Irrigated Class 8</td><td>153</td><td>0%</td></tr>
<tr><td>Non-Applicable</td><td>220</td><td>1%</td></tr>
<tr><td>Total (Parcel Acres)</td><td>30,968</td><td>100%</td></tr>
</table></td></tr>
<tr><td>Classification of prime and unique farmland soils</td><td>About two thirds of the AG property are prime farmland or prime farmland if drained or protected from flooding. Another 10% is farmland of statewide importance. See Exhibit L.</td></tr>
<tr><td>Availability of public facilities, including roads used in transporting agricultural</td><td>AG zoned properties lie along roads that may be used to transport goods. See Exhibit J.</td></tr>
</table>

WAC 365-190-050 Criteria Summary	AG 10 Zone Characteristics
products	
Tax status, including current use tax assessment	More than half of the AG acreage is in current use taxation (see Exhibit I).
Availability of public services	AG zoned properties have access to police, fire, parks, and schools across the county. Response times for emergency services are potentially greater in the further reaches of the county.
Relationship or proximity to urban growth areas	The AG zoning is applied to properties surrounding urban growth areas, particularly LaCenter, Ridgefield, Battleground, and Vancouver. See Exhibit J.
Predominant parcel size	The median parcel size is 5.1 acres. About 44% of parcels are less than 5 acres and another 39% are 5-20 acres in size. Some land is in contiguous ownership. See Exhibit G and Exhibit H.
Land use settlement patterns and their compatibility with agricultural practices	Typically AG zoned property abuts Rural zoned property. Per the current use taxation program and the WSDA inventories, agriculture is often occurring in Rural zoned land as well as AG zoned land, which is compatible in use. See Exhibit F. In some cases AG land directly abuts UGAs where there would be a greater intensity of use in UGAs.
Intensity of nearby land uses	See land use settlement criteria above.
History of land development permits nearby	Based on a review of Clark County GIS information online, building, site plan, and subdivision permits are more prevalent in UGAs than in unincorporated lands due to the greater population and parcels with the UGAs. (http://gis.clark.wa.gov/mapsonline/)
Land values under alternative uses	Land values for non-agricultural uses are greater than for agricultural uses. Thus, more than half of the AG zoned property owners participate in the current use taxation program (see Exhibit I).
Proximity to markets	AG zoned properties lie in proximity to several communities including Vancouver, Battleground, LaCenter, Ridgefield, and others. See Exhibit J.
May consider food security, local food, artisans	In Clark County the number of small farms has been increasing over time, and represents more intensive, value-added, urban-oriented farming. The Clark County Food System Council addresses food security in the County and is promoting the use of locally grown food. As noted in Section 3.2, Clark County has high numbers of farms participating in CSAs and selling directly to consumers. Clark County had 39 farms that marketed products through community supported agriculture (CSA). This is the second highest in the state after King County with 46 farms marketing through CSAs. Clark County had 141 farms that produced and sold value-added commodities, third highest in the state after Yakima (187) and King (163).
Designating agricultural resource lands sufficient to maintain and enhance the economic viability of the ag. industry in County over long-	The number of Clark County farms has increased since 1997. While most farms in Clark County are small in terms of value of output or size, they represent a local food network. See food security discussion above. Measures to address the needs of farmers (e.g. access to farmland and homes) while protecting the land base (e.g. clustering or building envelope criteria) would help retain

WAC 365-190-050 Criteria Summary	AG 10 Zone Characteristics
term	agriculture uses on the land. See Sections 3.1 and 3.2 for more information.

Source: BERK Consulting 2016

Exhibit L. Prime Farmland – AG 10 Zone



Source: Clark County Community Planning, NRCS USDA, BERK Consulting 2016

2.6 Trends in Forestry

The location of forestry can be gleaned from a synthesis of the Current Use Taxation Program and the County's forest land use designation (Exhibit M). Most of the County's designated land of long-term commercial significance is identified as Forest Tier I and has a zoning standard of 80-acre lots.

Most of the County's Forest Tier II – currently 40 acres and proposed at 20 acres in the Forest 20 zone – applies to properties with smaller lot size. Most of the Forest 20 lots are less than or equal to 20 acres in size (89%), and most of the Forest 20 lots have homes on them. See Exhibit L.

Exhibit M. Distribution of Parcel Sizes in Forest 20 Zones

Size	Number of Parcels	Percent of Total Number Parcels	Parcel Acres	Percent of Total Parcel Acres	Housing Units	In Current Use Timber	In Current Use Designated Forest Land
<=5 Acres	2,514	63%	3,056	10%	1,312	54	48
5-10 Acres	640	16%	4,214	13%	432	178	57
10-20 Acres	417	10%	6,543	21%	227	187	64
20+ Acres	446	11%	17,980	57%	227	98	182
Total	**4,017**	**100%**	**31,792**	**100%**	**2,198**	**517**	**351**

Source: Clark County Assessor, BERK Consulting 2016

There is limited information about the size of a commercially viable forest holding. The State of Washington Department of Natural Resources and Department of Revenue tracks revenues on stumpage from forest harvest and considers small private holdings to be less than 5,000 acres. The Washington State Department of Natural Resources notes that small forest landowners own 3.2 million acres of Washington forests[3] – about half the private forestland in the state. The State has a program for Small Forest Landowners that have produced less than average timber volume of two million board feet per year stumpage over a 3-year period. Access to programs that offer funding require a property of at least 10 acres in size for stewardship activities or more than 20 acres for the forestry riparian easement program.

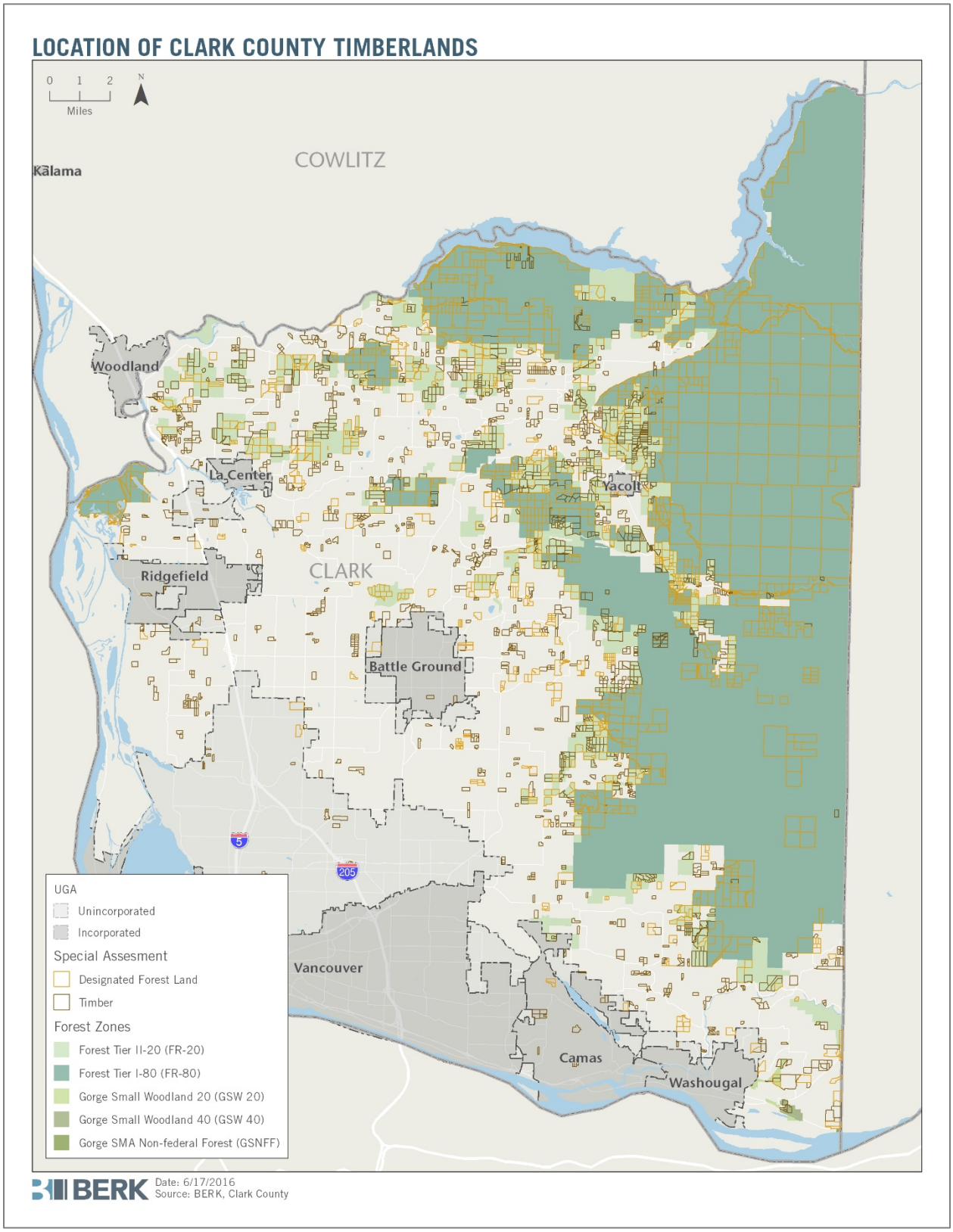
About 22% of all Forest 20 parcels are in current use taxation, per Exhibit L, allowing lower taxes for maintaining the land in forestry; per Exhibit M, the parcels in current use taxation that are designated as forest lands are extensive.

The current use taxation program criteria for either timberland or designated forestland is based on the following size and character of forest lands: Have a minimum of 5 contiguous acres in the same ownership, not including any residential home sites, be actively growing timber for commercial harvest, and be compliant with forest practice laws and regulations.

The minimum current use taxation program acreage is 5 acres. It was reduced from 20 acres to 5 acres in 2014 legislation.

[3] See website: http://www.dnr.wa.gov/sflo.

Exhibit N. Location of Clark County Timberlands (RLS Exhibit 22)



Source: Clark County Assessor, 2016; BERK, 2016.

There are criteria for designation of forestland as of long-term commercial significance under State rules (WAC 365-190-060).

The other criteria include, in summary:

- In classifying and designating forest resource lands, counties must approach the effort as a county-wide or regional process.
- Lands should be designated as forest resource lands of long-term commercial significance based on three factors:
    - The land is not already characterized by urban growth.
    - The land is used or capable of being used for forestry production.
    - The land has long-term commercial significance; this includes determining which land grade constitutes forest land of long-term commercial significance, based on local physical, biological, economic, and land use considerations. However, the presence of lower private forest land grades within the areas of predominantly higher grades need not preclude designation as forest land.
- Counties and cities must also consider the effects of proximity to population areas and the possibility of more intense uses of the land:
    - The availability of public services and facilities conducive to the conversion of forest land;
    - The proximity of forest land to urban and suburban areas and rural settlements: Forest lands of long-term commercial significance are located outside the urban and suburban areas and rural settlements;
    - The size of the parcels: Forest lands consist of predominantly large parcels;
    - The compatibility and intensity of adjacent and nearby land use and settlement patterns with forest lands of long-term commercial significance;
    - Property tax classification – current use assessment;
    - Local economic conditions which affect the ability to manage timberlands for long-term commercial production; and
    - History of land development permits issued nearby.
- Counties and cities may also consider secondary benefits from retaining commercial forestry operations. Benefits from retaining commercial forestry may include protecting air and water quality, maintaining adequate aquifer recharge areas, reducing forest fire risks, supporting tourism and access to recreational opportunities, providing carbon sequestration benefits, and improving wildlife habitat and connectivity for upland species.

A primary criteria is related to soil capabilities. Much of the County has the appropriate ratings for forestland. See Exhibit O. About 20% of parcels representing significant acreage is in current use taxation (see Exhibit L and Exhibit M). Much of the designated forest land is located further east of the settled areas of the county. Regarding parcel size, the County is retaining larger parcel sizes for Tier I land, and is considering changing the Forest 40 to Forest 20. This acreage size is in the range considered by other counties, as described further in Section 3.3. Some counties address clustering and other techniques to allow the continuation of forestry activities. As described above, the State offers assistance to smaller forestry owners to encourage stewardship. The combination of criteria in the rules led to the designation of forestland in the Comprehensive Plan in 1994 as updated in 1998, and conditions are similar today.

Exhibit O. Soil Capabilities for Forest Use

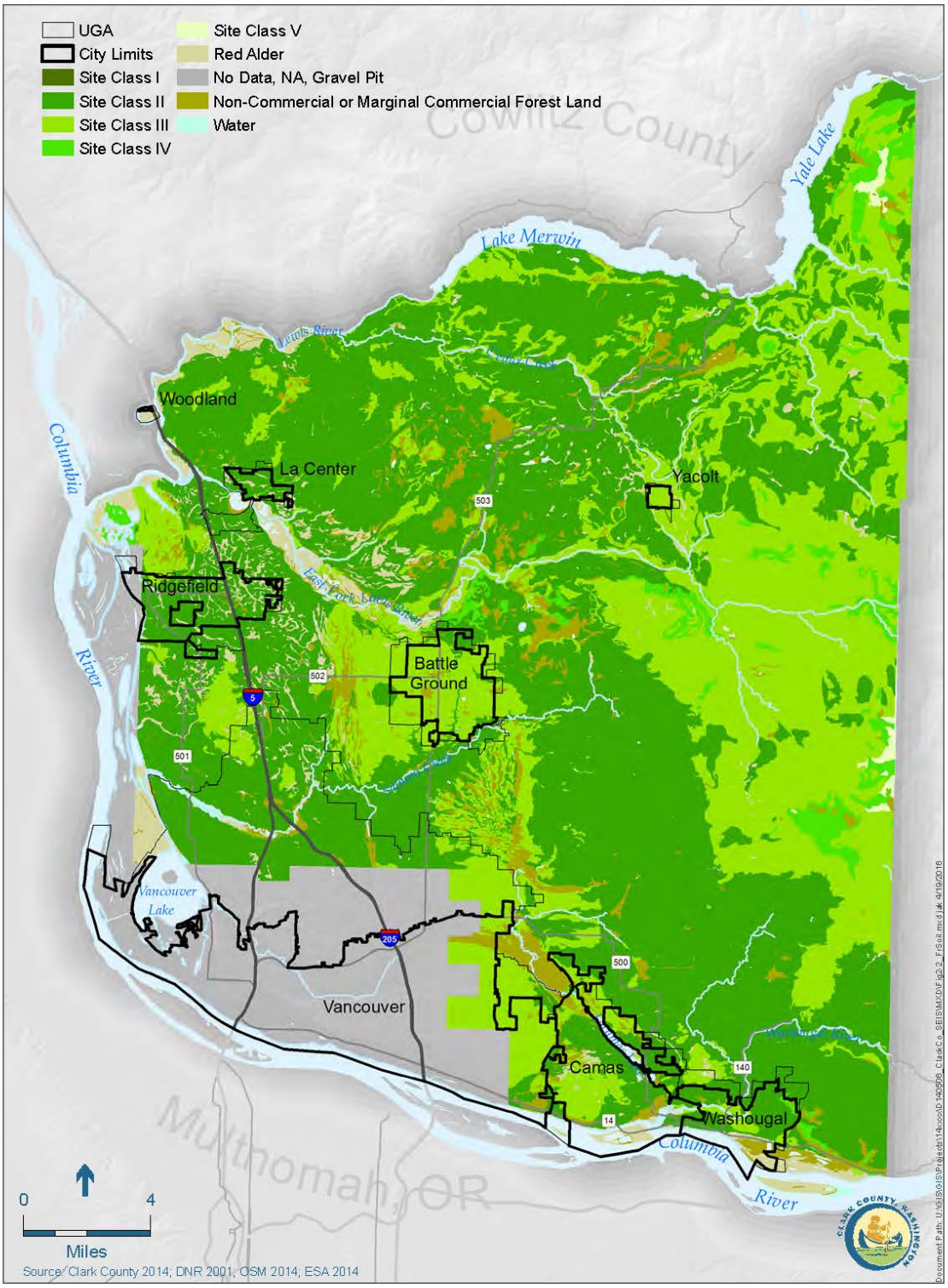


Figure 2-2: Soil Capabilities for Forest Use

Source: Clark County Comprehensive Plan Update, Final SEIS, April 2016

II. LITERATURE REVIEW AND EXAMPLE COUNTIES PROVIDING REGULATORY SUPPORT FOR PRODUCERS

3.0 PURPOSE AND BACKGROUND

The Rural Lands Study also included an analysis examining the County's rural and resource lands policy objectives, Growth Management Act (GMA) parameters, and other planning examples that, together with the market assessment offered some possible policy and code development options. Policy options included a variety of tools such as homesteading, clustering, and others.

Part II of this supplemental analysis updates the status of rural and resource conservation tools by example counties. This part of the issue paper also involves a brief review of existing reports or literature regarding the economic need to support agriculture with a resident population (residents on the agricultural land); and the relationship of smaller agricultural operations and proximity to urban markets (farm to market, etc.).

3.1 Agricultural Zoning

Example Counties in Washington State

Western Washington Counties addressing agricultural activities are highlighted below in Exhibit N. All counties have a median farm size of 20 acres or less, with particularly populous counties such as Pierce, King, and Snohomish having median farm sizes of about 10 acres similar to Clark County. These latter counties have minimum agricultural zone parcel sizes of 10 acres. All but Skagit County allow residential uses. Most have lot or building standards designed to protect agricultural soils and agricultural activities (King, Snohomish, Skagit, and Whatcom Counties) such as through building siting standards, lot depth/width standards, land use restrictions, or lot aggregation requirements. Pierce, Skagit, and Whatcom Counties allow or require clustering.

Exhibit P. Example County Regulations in Agricultural Zones – Western Washington

County	2012 Median [Average] Farm in Acres	Agricultural Zoning– Min. Lot Size (Acres)	Dwellings Allowed	Lot / Building Standards Promoting Farming	Clustering
Clark County **2015 Pop: 451,820**	10 [39]	20	Yes	Not required. Building envelope siting criteria are under consideration.	Clustering not allowed on Resource Lands. Reconfiguration of nonconforming lots is allowed on AG zoned land but is not required.
Pierce County **2015 Pop: 830,120**	10 [33]	10	Yes	Not required. Policies call for reduced or eliminated processing fees for subdivisions for the purpose of recombining substandard lots.	Clustering allowed on most ARL lands. Residential density may be increased to a max. of 1 DU / 5 acres on properties of 20 acres +. Max 10 lots per cluster; only 1 lot may be greater than 1 acre (limited to 10% impervious).

County	2012 Median [Average] Farm in Acres	Agricultural Zoning– Min. Lot Size (Acres)	Dwellings Allowed	Lot / Building Standards Promoting Farming	Clustering
King County **2015 Pop: 2,052,800**	8 [25]	10, 35	Yes	Standards include a Maximum Lot Depth/Width Ratio of 4 to 1 to promote farming and avoid homes on long narrow lots.	Clustering not allowed on AG Resource Lands.
Snohomish County **2015 Pop: 757,600**	10 [49]	10	Yes	New lot can be less than 10 acre standard if exclusively agriculture use. New dwellings on existing legal lots within farmlands or on parcels adjacent to farmlands allowed; require a resource protection area easement on balance. Lot consolidation required for three or more contiguous lots created prior to 1957.	Clustering not allowed on AG Resource Lands. Required on Rural lands adjacent to designated local or commercial farmland.
Skagit County **2015 Pop: 120,620**	20 [99]	40	No, unless certified as a legal lot prior to 2005.	Siting criteria required in Agricultural zone. Addresses onsite and offsite compatibility. Limits development to 1 acre in extent.	Clustering allowed.
Whatcom County **2015 Pop: 209,790**	16 [68]	Agriculture: 40 Agriculture Protection Overlay: 5, 10, 20	Yes on lot of record.	Required to consolidate adjacent tracts in same ownership. APO has onsite siting criteria for clustered lots.	Clustering required on Rural lands with Agriculture Protection Overlay (cluster on 25% of land). Clustering under consideration on Resource lands. Homesteads allowed on AG 40 properties: A farmstead parcel between 1 and 3 acres in size can be established by boundary line adjustment or agricultural short plat to recognize an existing home, plus accessory structures. There can be no increase in allowable density and the remaining non-residential lot cannot be further subdivided (a note must be recorded).

Source: Code Publishing Co. or County-published Codes, BERK Consulting 2016

Some of the example counties are in the midst of addressing agricultural resource lands policy and zoning issues, including:

- In 2016, the Pierce County Council authorized funding a study of agriculture and ARL "conducting an evaluation and providing a report on agricultural land in Pierce County that has long-term significance for the commercial production of food or other agricultural products." It may lead to remapping of ARL land since tasks include looking at the County's mapping criteria that address

parcel size and yield. It also includes elements similar to the Clark County Rural Lands Study in terms of looking at the market economics and conducing qualitative outreach with farmers.

- Much of Whatcom County's resource land base is designated for AG-40, allowing 40 acre lots. However, to achieve the County's goals of an agricultural industry of 100,000 acres or more, the County has protected agriculture on smaller Rural zoned lots through an Agricultural Production Overlay (APO) zone. Recently, the County has been considering whether to rezone these Rural / APO zoned lots to Agriculture zones allowing smaller lot sizes more consistent with the patterns observed in the area. In 2015 and 2016, Whatcom County evaluated these as Rural Study Areas (RSAs). The County may consider rezoning these RSAs (comprising 21,950 acres) from their respective Rural Districts (R-5A and R-10A) to Small Lot Agriculture Districts (Ag-5 or Ag-10) at densities higher than the County's current Agriculture Zone (Ag-40). The Small Lot Agriculture District is anticipated to add heightened protection to these productive agricultural areas by: 1) reducing the types and number of non-agricultural uses and increasing the types and number of permitted agricultural uses in these areas; and 2) reducing the likelihood of the affected parcels being taken out of agricultural use by rezoning them to increase residential density in the future.

Other National Examples

The issue of balancing an allowance for home sites and agriculture is a common one across the country. Two examples of how that balance is achieved are presented below.

WISCONSIN. The Wisconsin Farmland Preservation Program is designed to help local governments and landowners preserve agricultural land, minimize conflicting land uses, and promote soil and water conservation. Owners of farmland who participate in the program receive an income tax credit incentive. Model zoning ordinances identify how a local government can craft regulations that are certified to meet the provisions of the state program. Generally, the model ordinances allows residences for farmers, and restrict nonfarm residences by requiring a conditional use permit for either a single nonfarm residence or a cluster of nonfarm residences. The new state standards encourage smaller residential lots that convert less farmland. There are siting standards for nonfarm residences to avoid converting active farmland or prime soils.

KALASKA COUNTY, MICHIGAN COMMUNITY CENTER, 2003 Zoning Techniques for Farmland Preservation**:** Information about land use planning including protecting resource lands was made available to the community, and was adapted from "Watershed Resource Papers" developed for the Dowagiac River Watershed Project by Langworthy, Strader, LeBlanc, & Associates, Inc. Various techniques are summarized that protect agriculture while accommodating housing, including: 1) Exclusive use zoning with limitations on new non-farm residences and other provisions such as a maximum lot to depth ratio of 1:3 and large minimum lot widths and setbacks; 2) Sliding scale zoning that limits the number of times that a parent parcel (a parcel existing on the date of ordinance adoption) can be split, based on its size but that does not require special land use permits; 3) "Quarter/quarter zoning" where a limited number of non-farm homes are allowed for every 40-acres of land; and 4) Cluster development that provides for a denser concentration of development in a limited area, with no increase in the overall, or "gross density" of the site.

3.2 Agricultural Literature Review

Supporting Agriculture with a Resident Population

More recently farmland preservation advocates and governmental agencies have identified the need to both protect farmland and support the farmers that farm the land.

NEW FARMS – BARRIERS AND GAPS, AMERICAN FARMLAND TRUST: Given an aging farmer population (more pronounced in Clark County as of 2012 similar to other counties), a recent paper examined how to help attract new farmers. The paper identified a gap for new farmers – gaining access to land particularly infrastructure and housing to support a new operation. Some solutions include farm link programs that list land offers, consulting services, transfers, and agreements from retiring farmers, etc. plus private land trusts.

- Freegood, Julia and Jennifer Dempsy, American Farmland Trust, 2014, Cultivating the Next Generation: Resources and Policies to Help Beginning Farmers Succeed in Agriculture:

WHATCOM COUNTY – FINANCING OF HOMES: Whatcom County explored amending its homesteading rules (onsite homes used by farmers or their heirs), building site location requirements to protect agricultural operations and prime soils, and allowing for newer forms of clustering without adding density:

- Presentation from Initial Review Team Meeting - February 2012 (PDF)
- Project Fact Sheet (PDF)
- Situation Assessment and Recommendations - May, 2012 (PDF)
- Supplemental Analysis - August, 2012 (PDF)

A focus group was convened with farmers, lawyers, and finance professionals to discuss current and potential regulations to support farmers and protect the land.

Finance professionals indicated that farmland owners enrolled in a current use tax deferral program can have trouble getting financing in the secondary market, and they expected that this problem would drive down the size of homestead sites. It is easier to obtain a loan to build a home for the farmer if smaller homesites are allowed (either traditional parcel or homestead parcel) because it allows the bank to consider a greater pool of comparable properties and more readily determine the loan cost. The banks would also be more assured as to the individual homesite access to utilities.

Whatcom County's proposed 2016 Comprehensive Plan Update includes policies advancing the code changes proposed in the study.

Relationship of Smaller Agricultural Operations to Urban Markets

More recent research has been compiled by the Congressional Research Service and USDA on smaller agricultural operations in urban markets:

- Johnson, Renee, et al. Congressional Research Service, 2013: The Role of Local Food Systems in U.S. Farm Policy, https://www.fas.org/sgp/crs/misc/R42155.pdf.

- Martinez, Steve, et al. Local Food Systems: Concepts, Impacts, and Issues, ERR 97, U.S. Department of Agriculture, Economic Research Service, May 2010, available: http://www.ers.usda.gov/media/122868/err97_1_.pdf

Research highlights are excerpted and focus on the growth in the value and extent of local food, the significant share of farms that are located in metropolitan areas, and the potential benefit of small farm proximity to urban areas in terms of customers as well as a source of labor and location of like-minded farmers to form coops to help support small farms' marketing efforts.

- In 2007, there were about 859,300 metropolitan farms in the United States, accounting for about 40% of all U.S. farms and about 40% ($115.7 billion) of the total value of U.S. agricultural production, according to USDA.

- Most farms (81%) engaged in direct-to-consumer sales are **"small" farms,** with annual farm sales under $50,000, totaling an estimated 86,700 farms in 2008. For smaller farms, direct marketing to consumers accounts for a higher percentage of their sales than for larger farms. Small farms with direct sales often engage in other entrepreneurial activities.

- The leading states with direct-to-consumer marketing sales in 2007 were California, New York, Pennsylvania, Michigan, Oregon, Ohio, **Washington,** Wisconsin, Massachusetts, and Texas.

- USDA reports that the value of direct-to-consumer food marketing increased in all U.S. producing regions from 1997 to 2007.

- Among the reasons cited for the increasing popularity of local foods are perceived higher product quality and freshness of local food; a desire to provide social and political support for local farmers and the local economy; farmland preservation; and others related to environmental and equity concerns. A desire to support nearby small and medium-sized farms is also a motivation for consumers.

- About four out of five respondents to a 2006 national survey said they purchased fresh produce directly from growers either occasionally or always (Keeling- 2 Local Food Systems: Concepts, Impacts, and Issues / ERR-97 Economic Research Service/USDA Bond et al., 2009).

- USDA reports that small farms rely more on direct-to-consumer marketing channels (farmers' markets, on-farm sales, roadside stands, CSAs, etc.) as compared to larger farms.

- Metropolitan farms are reported to have a different product mix than farms in non-metro areas, and consist of mostly high-value crops, such as fruits and vegetables, and also livestock and dairy products.

- Significant costs of direct marketing and on-farm processing, especially those related to time and labor, can present obstacles to expansion of local food sales. This may be partially alleviated by proximity to metro areas and farmers markets. Other solutions are to pool resources through coops, training of new farmers, and other techniques.

- Most policy issues facing farmers' markets develop at the local level because farmers' markets are a local activity (Hamilton, 2005). The most commonly encountered local policy issues relating to farmers' markets are operational questions, such as where the market can operate, parking, security, and conflicts with adjacent businesses. These policies can be significant factors. Farmers' markets have been found to have positive impacts on local economies.

Within the literature cited, maps identified Clark County as having 20-40% of farms with direct sales in 2007. More recent Census of Agriculture 2012 information shows:

- Clark County had 39 farms that marketed products through community supported agriculture (CSA). This is the second highest in the state after King County with 46 farms marketing through CSAs.

- Clark County had 141 farms that produced and sold value-added commodities, third highest in the state after Yakima (187) and King (163).

Combined with the trend information in Section 2.0 regarding the prevalence of very small farms by value and the relatively small agricultural parcels found throughout the AG zone and Rural zoned areas, this information on direct sales and entrepreneurism shows that Clark County is an example of the local food movement and is benefiting by having farms in proximity to urban markets to meet customer preferences. Clark County's agriculture continues to reflect the findings of the 2012 Rural Lands Study:

> *Key Finding #1: Agriculture in Clark County in 2011 is in the midst of a decade's long transition from large scale commodity farming into more intensive, value-added, urban-oriented farming.*
>
> *Key Finding #2: Large farm and mid-size farms are declining in number, acres, and value. However, they remain a viable enterprise but face a multitude of challenges.*
>
> *Key Finding #3: A Diverse set of small farms and enterprises are increasingly becoming part of the rural landscape.*

3.3 Forestry Zoning

Western Washington Counties have a range of lot sizes for forest lands, from 20 to 80 as shown in Exhibit O. Clustering is allowed in Pierce, Skagit, and Snohomish Counties, in whole or in part.

Exhibit Q. Example County Regulations on Forestry Lands – Western Washington

Policy Topic	Forestry Lot Sizes	Residential Allowances	Clustering
Clark County	40, 80	Allowed.	Not allowed on Resource Lands – under consideration.
Pierce County	80	Allowed.	Residential density may be increased to a max. of 1 DU / 5 acres on properties of 20 acres +. Max 10 lots per cluster; only 1 lot may be greater than 1 acre (limited to 10% impervious).

Policy Topic	Forestry Lot Sizes	Residential Allowances	Clustering
King County	80	Allowed. However, disturbance is limited to 3 acres.	Not allowed on Resource Lands
Snohomish County	20, 80	Allowed only on Local Forest.	The county shall not approve subdivision of land designated Commercial Forest beyond the 1/du/80 acres, except for subdivision to allow installation of communication and utility facilities. Land designated local forest shall not be divided into lots or parcels of less than 20 acres in size except through a rural cluster subdivision. 500 foot setback to structures on commercial forest land.
Skagit County	20, Secondary Forest 80, Industrial Forest	Yes, subject to onsite location requirements	Yes, on Forestry and Rural Resource lands.
Whatcom County	20, 40	Allowed only on Rural Forest land not Commercial Forest Land. Lot width/depth standards apply.	No.