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## Public Opinion, Traffic Performance, the Environment, and Safety After Construction of Double-Lane Roundabouts

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# Intersection crashes

2012

- 42% of all police-reported crashes
- 46% of injury crashes
- 23% of fatal crashes
  - 7,696 deaths

# Safety benefits of converting traditional intersections to roundabouts

European, Australian, and U.S. research

- 35-61% reductions in all crashes
- 25-87% reductions in injury crashes
- Greater safety benefits for single-lane roundabouts than for double-lane roundabouts
  - Smaller reductions in crashes at double-lane roundabouts, or
  - Increases in crashes at double-lane roundabouts

# Traffic and environmental benefits of converting traditional intersections to roundabouts

## Previous research

- 13-89% reductions in vehicle delays
- 14-52% reductions in the proportion of vehicles stopped
- Vehicle emissions and fuel consumption reduced
- Roundabout construction often part of larger construction project; unclear in prior studies whether effects of roundabouts separated from other construction effects

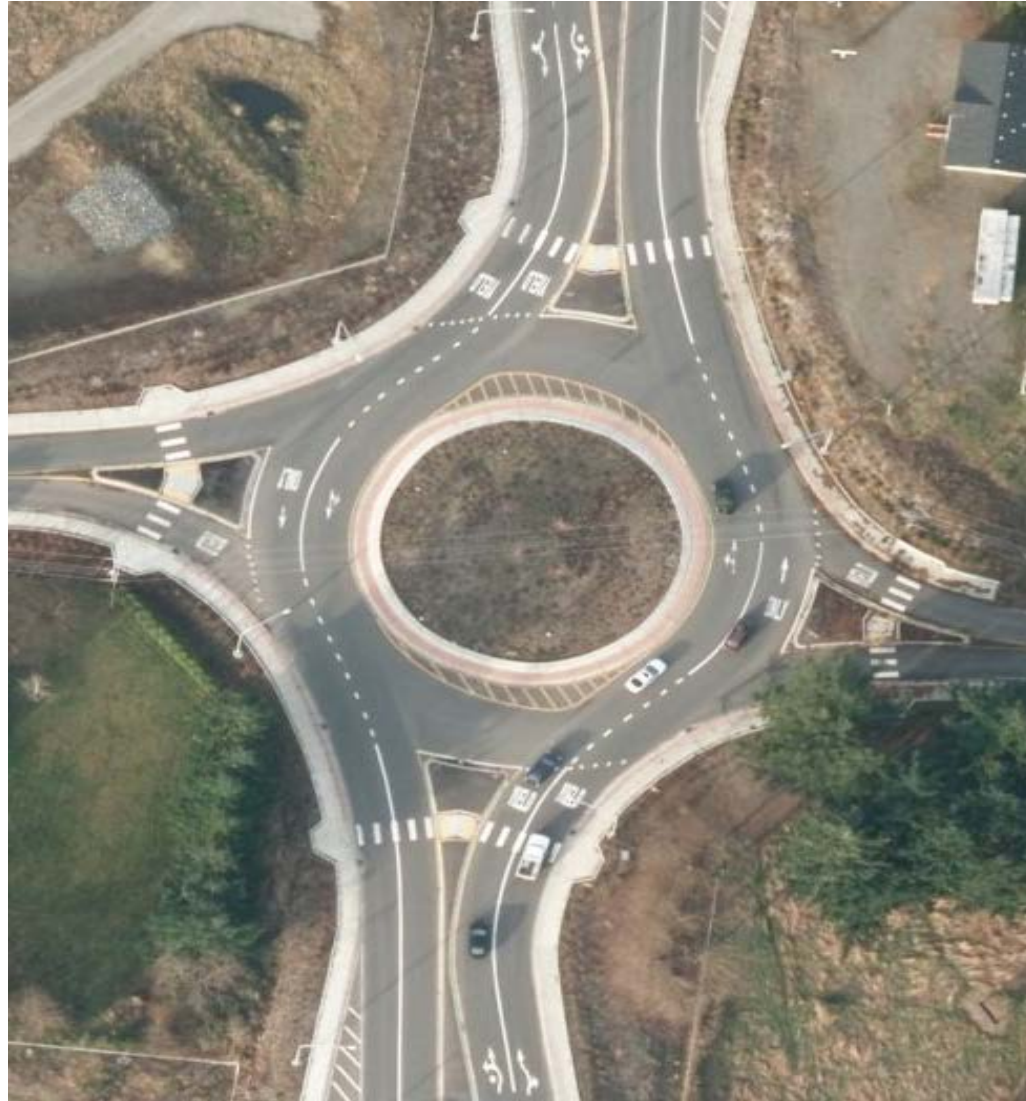
# Potential benefits of roundabouts for older drivers

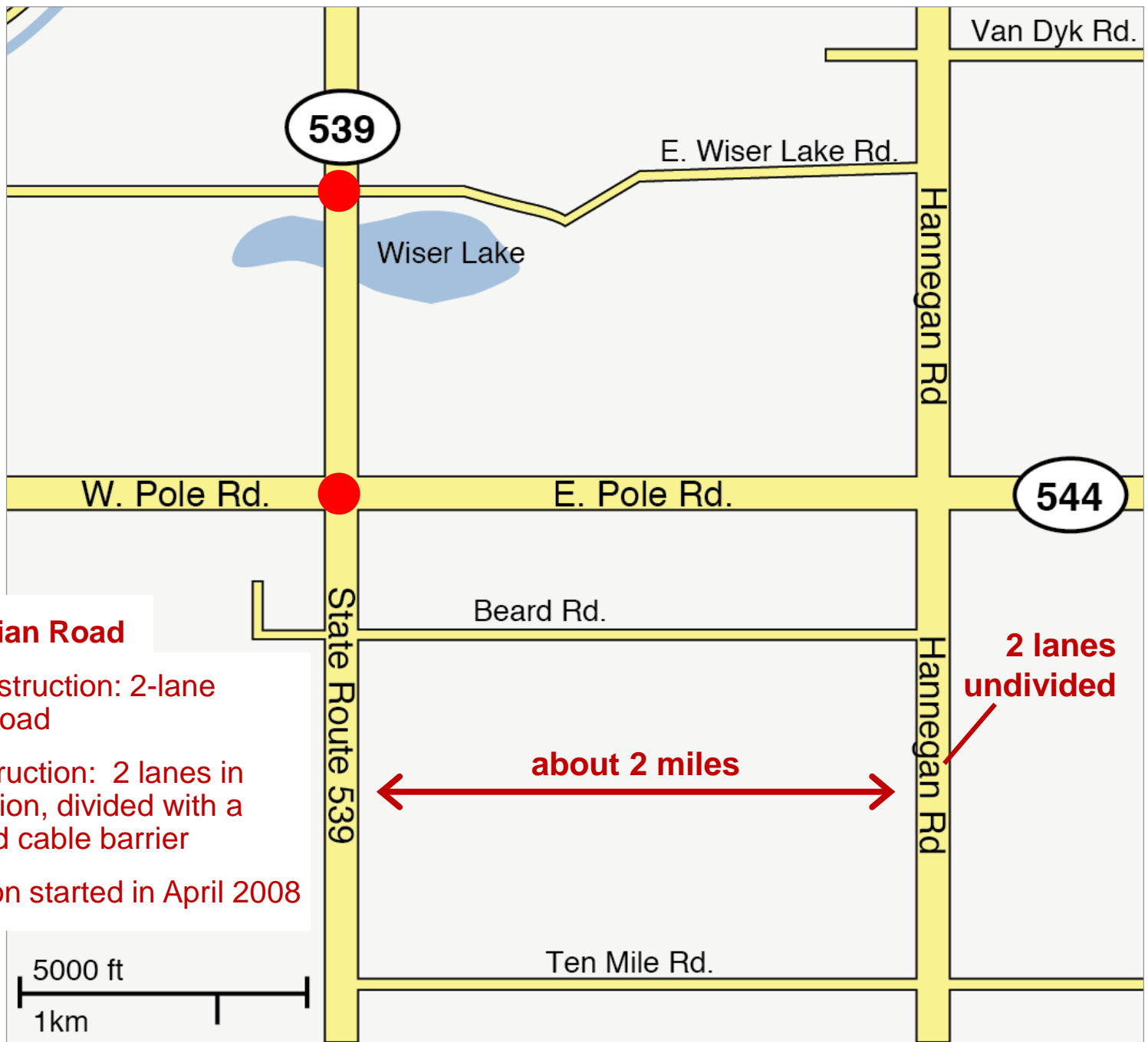
- Older drivers are over-involved in intersection crashes
- A study of at-fault drivers in nonfatal intersection crashes found older drivers more likely than younger drivers to be cited for failure to yield the right-of-way
- Consequences of failing to yield likely less severe at roundabouts than at traditional intersections
- A 2007 study found support for roundabouts was lower among drivers 65 and older than among younger drivers 1 year or longer after construction
- Concerns that older drivers will choose alternative routes to avoid roundabouts

# Study of conversions of two traditional intersections to double-lane roundabouts near Bellingham, Washington

- Limited research on multi-lane roundabouts in the United States
- Evaluate the impacts of the double-lane roundabouts on:
  - Public attitudes
  - Traffic performance and the environment
  - Crashes
- Evaluate whether older drivers avoided roundabouts by taking an alternative route

# Study roundabout





### Guide Meridian Road

- Before construction: 2-lane undivided road
- After construction: 2 lanes in each direction, divided with a median and cable barrier
- Construction started in April 2008



# Study roundabouts

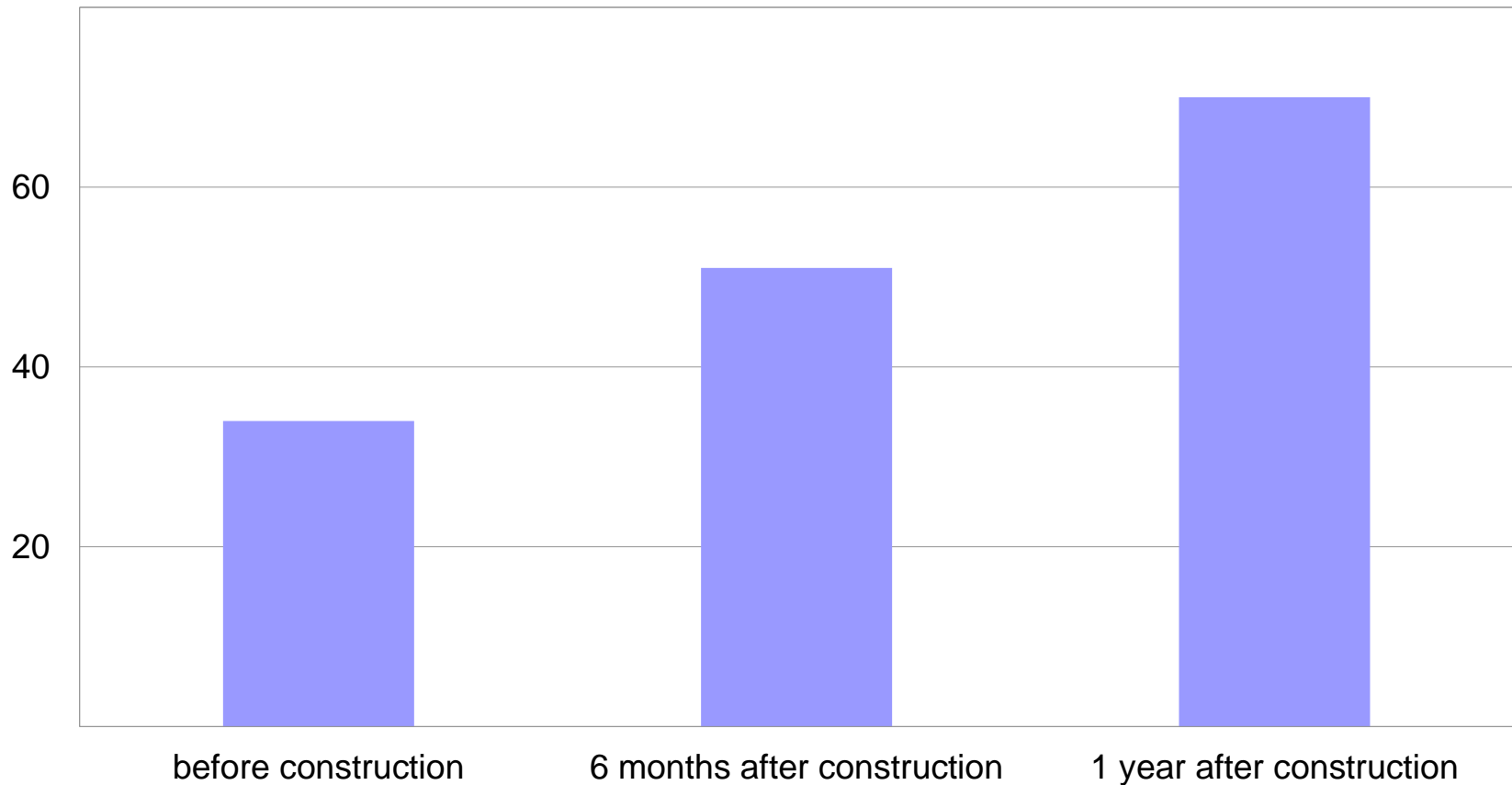
- Guide Meridian-Pole Road roundabout
  - Traffic signal-controlled before conversion
  - Fully operational in August 2009
- Guide Meridian-Wiser Lake Road roundabout
  - Two-way stop-controlled before conversion
  - Fully operational in October 2009



# Public attitudes and perceptions

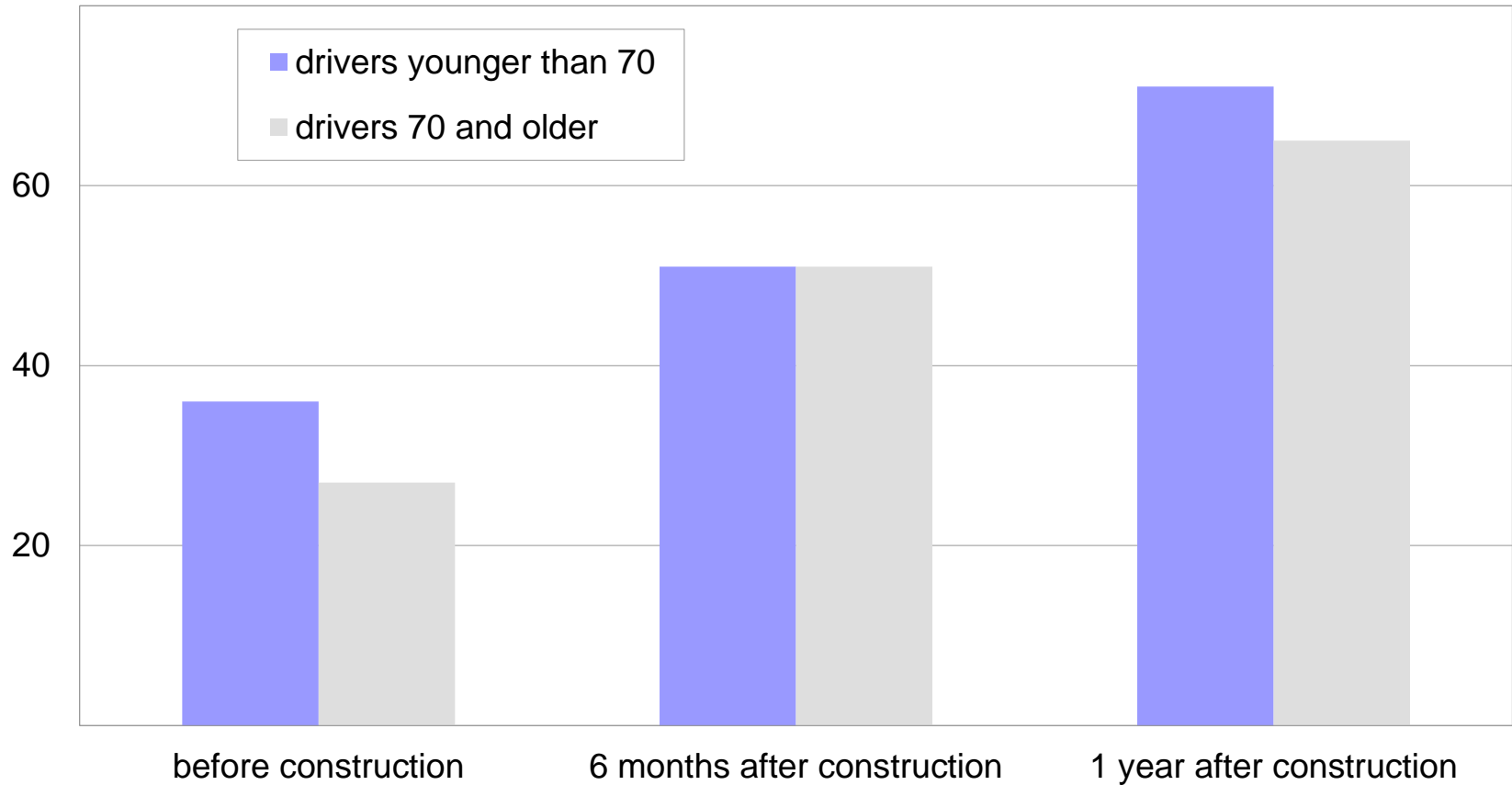
# Percent of drivers who support roundabouts

Telephone surveys of Bellingham area residents



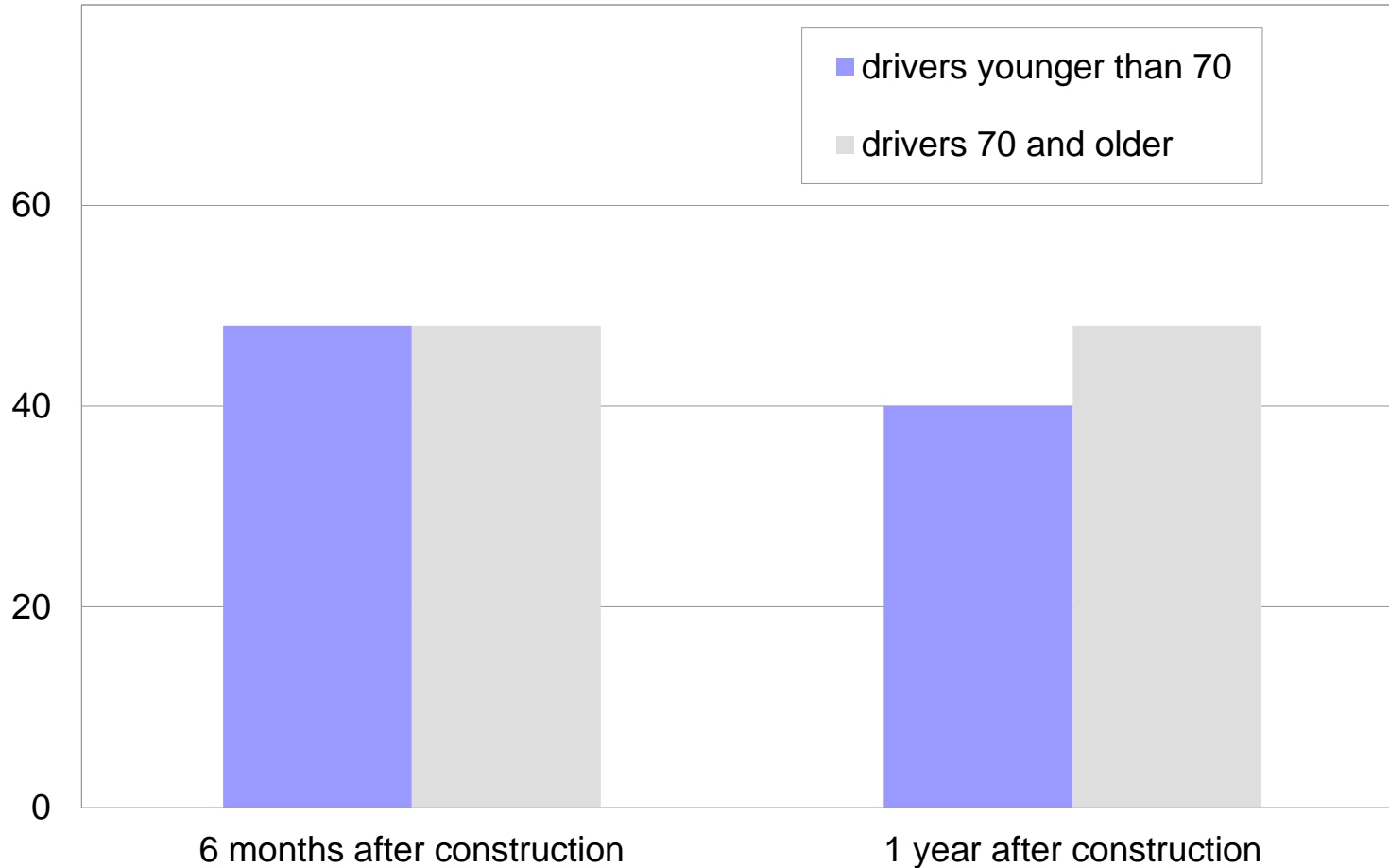
# Percent of drivers who support roundabouts

By driver age



# Percent of drivers who reported taking an alternate road to Guide Meridian

By driver age



# Reasons for opposing roundabouts

- Top reason before and after construction
  - Roundabouts are unsafe
- Other frequent responses before construction
  - Roundabouts are confusing
  - Prefer traffic signal
- Other frequent responses 6 months and 1 year after construction
  - Problems with right-of-way or yielding
  - Problems with large trucks

# Percent of drivers who agreed that signs and pavement markings clearly conveyed...

One year after construction

that drivers are approaching a roundabout	88
which lane drivers needs to be in to exit	69
what speed drivers should travel	59
which lane has the right-of-way to exit	55
that drivers should not drive beside large trucks in a roundabout	52



# Traffic performance analysis



# Data and modeling software

- Traffic recorded during 7 a.m. – 7 p.m. on three weekdays shortly before and 4 months after roundabout construction
- Peak hour traffic analyzed: 7 a.m.– 9 a.m., 11 a.m.– 2 p.m., and 4 p.m.– 6 p.m.
- Intersection characteristics before and after roundabout construction obtained from Washington DOT
- Analysis performed with SIDRA INTERSECTION 5.1
  - Highway Capacity Manual 2010 model

# Traffic performance analysis scenarios

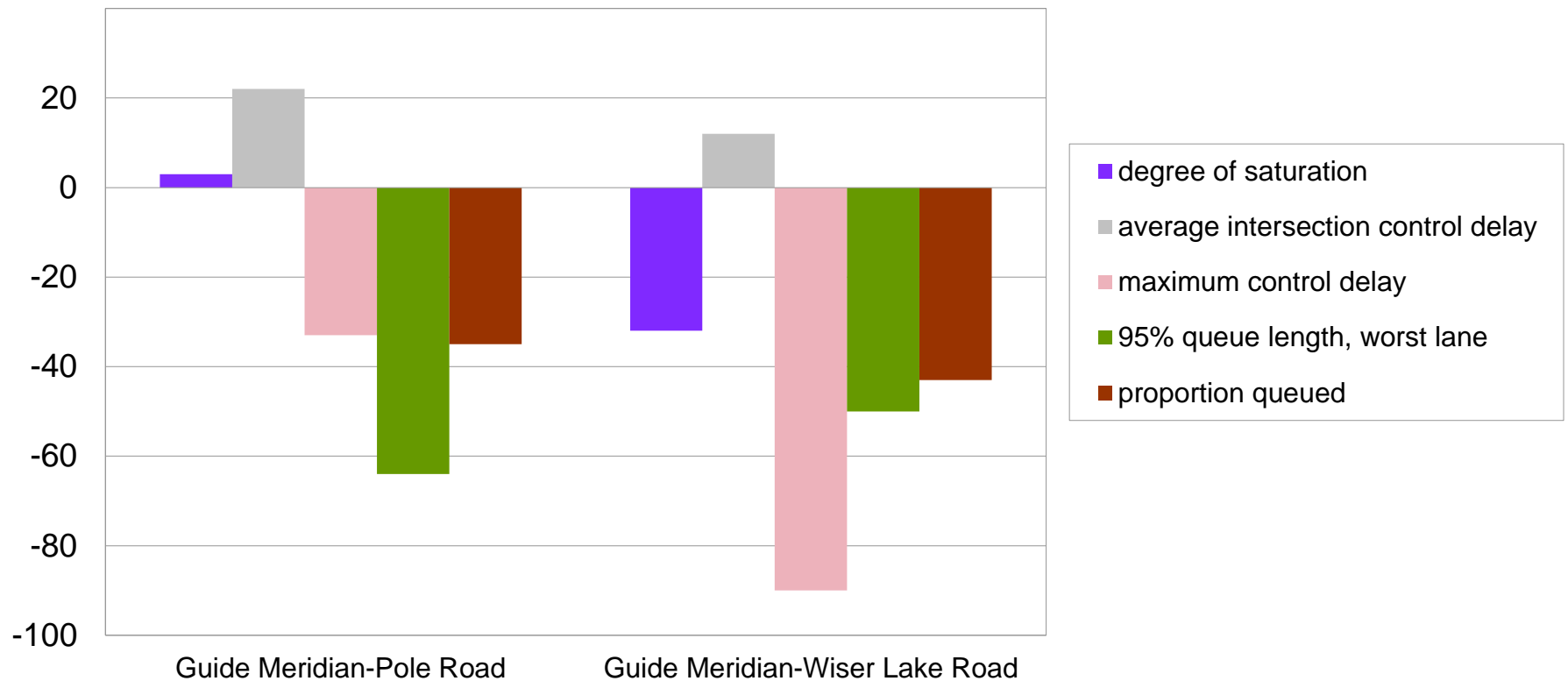
- To isolate effects of roundabout conversions from increased traffic capacity, hypothetical intersections were developed with original traffic controls but additional travel lanes
- Traffic performance evaluated for:
  - Before-construction intersections with before traffic volumes
  - Before-construction intersections with after traffic volumes
  - Hypothetical intersections with after traffic volumes
  - Roundabouts with after traffic volumes
- Effects of roundabouts estimated as difference between roundabout performance and hypothetical intersection performance

# Measures of traffic performance and environmental effects

- Traffic performance
  - Degree of saturation, or vehicle/capacity ratio
  - Average intersection control delay
  - Maximum control delay
  - 95% queue length of the worst lane
  - Proportion queued
  - Level of service
- Environmental effects
  - Fuel consumption
  - Emissions of carbon dioxide, hydrocarbon, carbon monoxide, and nitrogen oxide

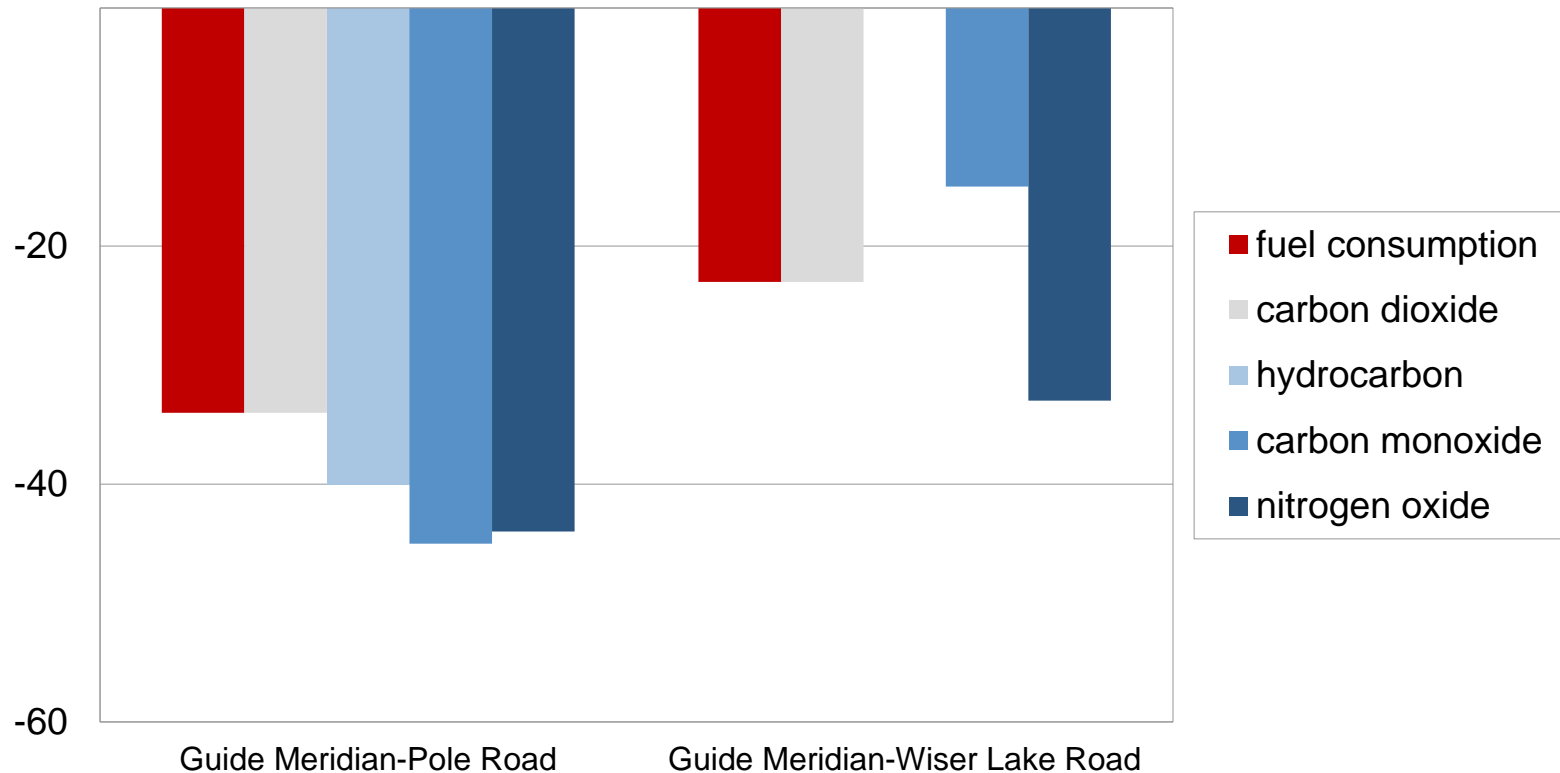
# Percent change in traffic performance measures

Roundabouts vs. hypothetical intersections with additional lanes



# Percent change in environmental measures

Roundabouts vs. hypothetical intersections with additional lanes





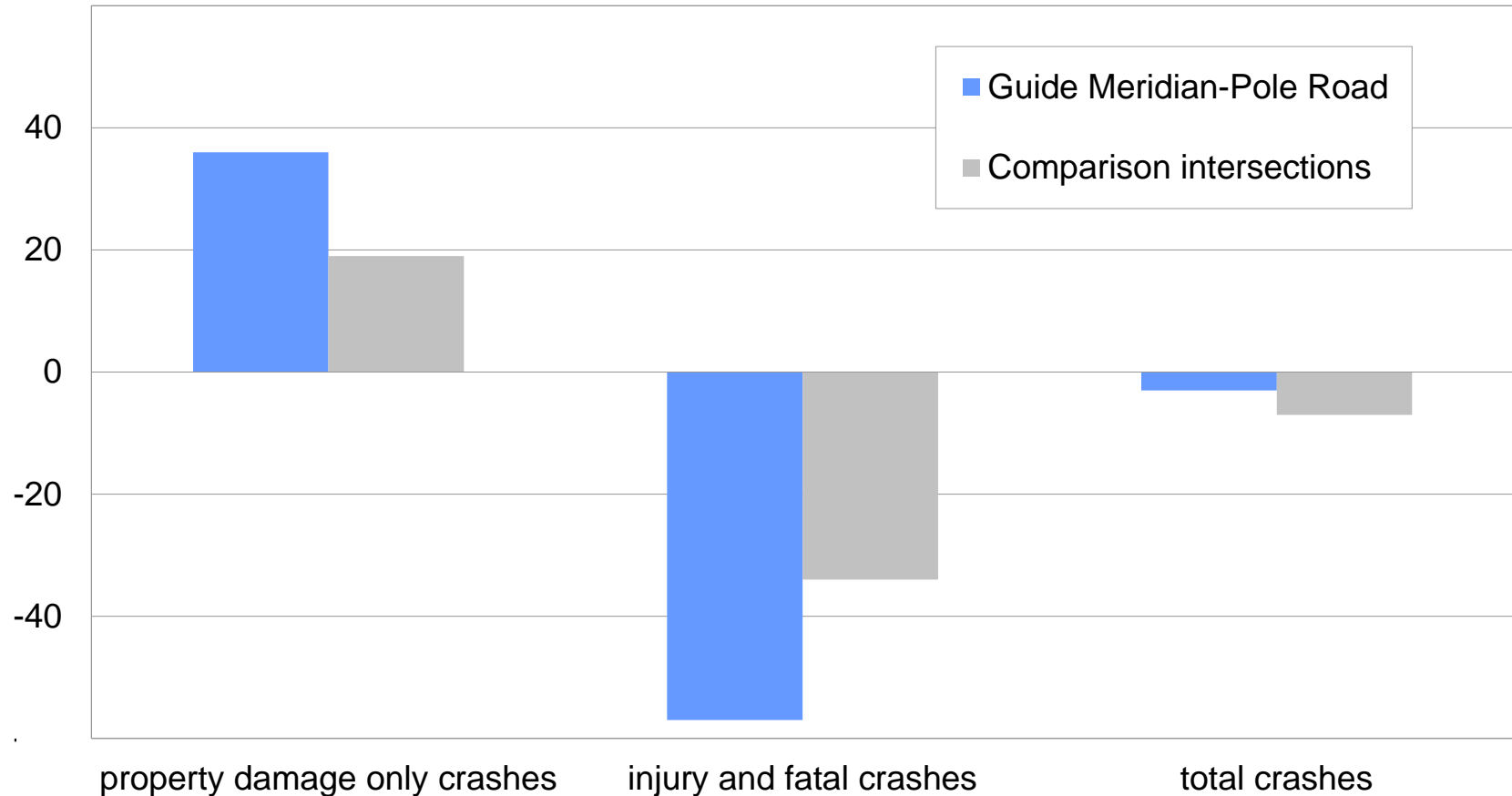
# Crash analysis

# Methods

- Before and after analysis with comparison intersections
- Selected comparison intersections based on similarity in traffic control, intersection layout, and traffic volumes
  - Guide Meridian-Pole Road: 5 sites
  - Guide Meridian-Wiser Lake Road: 8 sites
- Study periods
  - Before: January 2003-December 2007
  - After: January 2010-December 2011
- Included crashes occurring at intersection or intersection-related
- Crash rates computed with average annual daily traffic counts
- Poisson regression for all crashes, property damage-only crashes and injury and fatal crashes combined

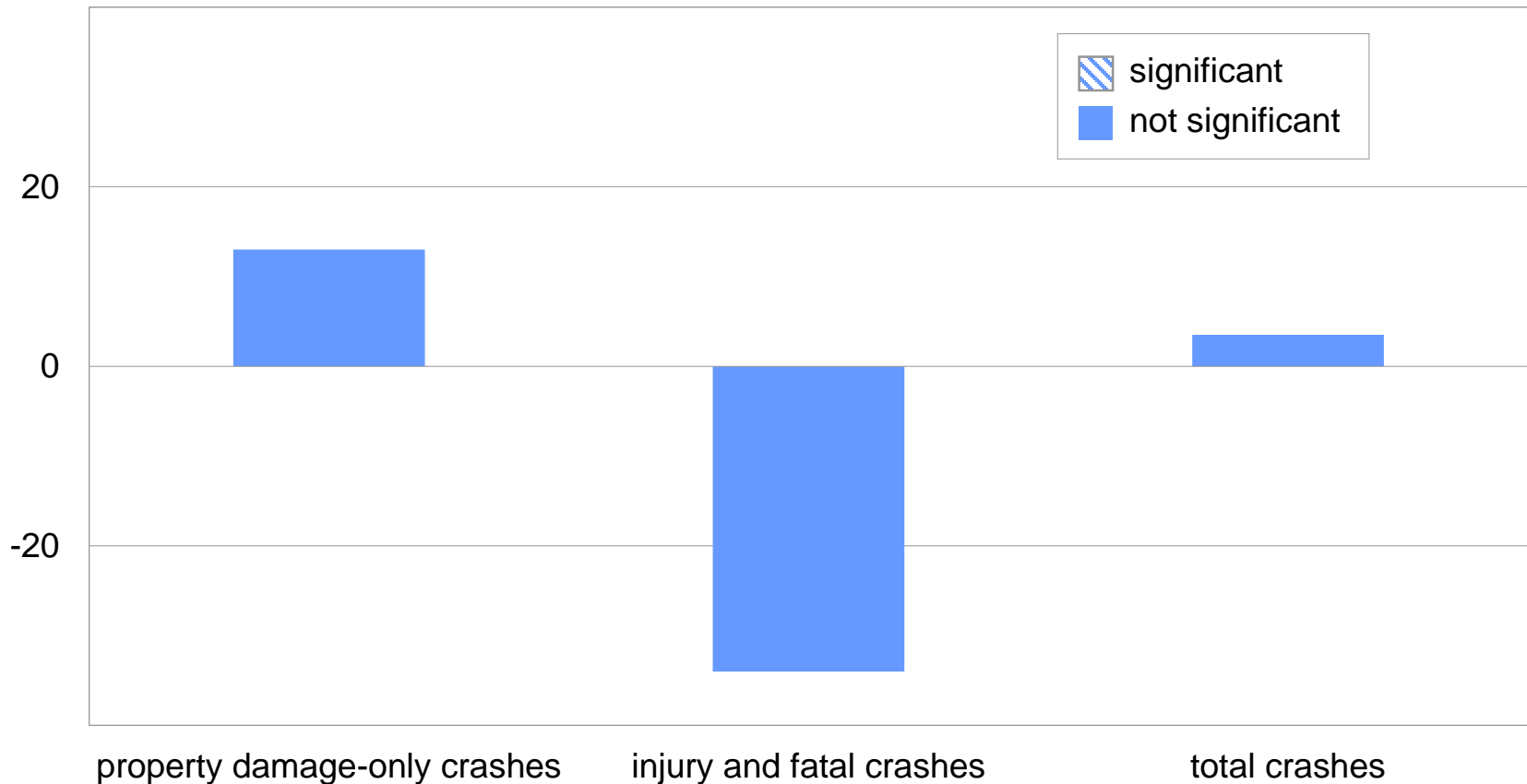
# Percent change in crash rates at Guide Meridian-Pole Road and comparison intersections

After vs. before roundabout construction



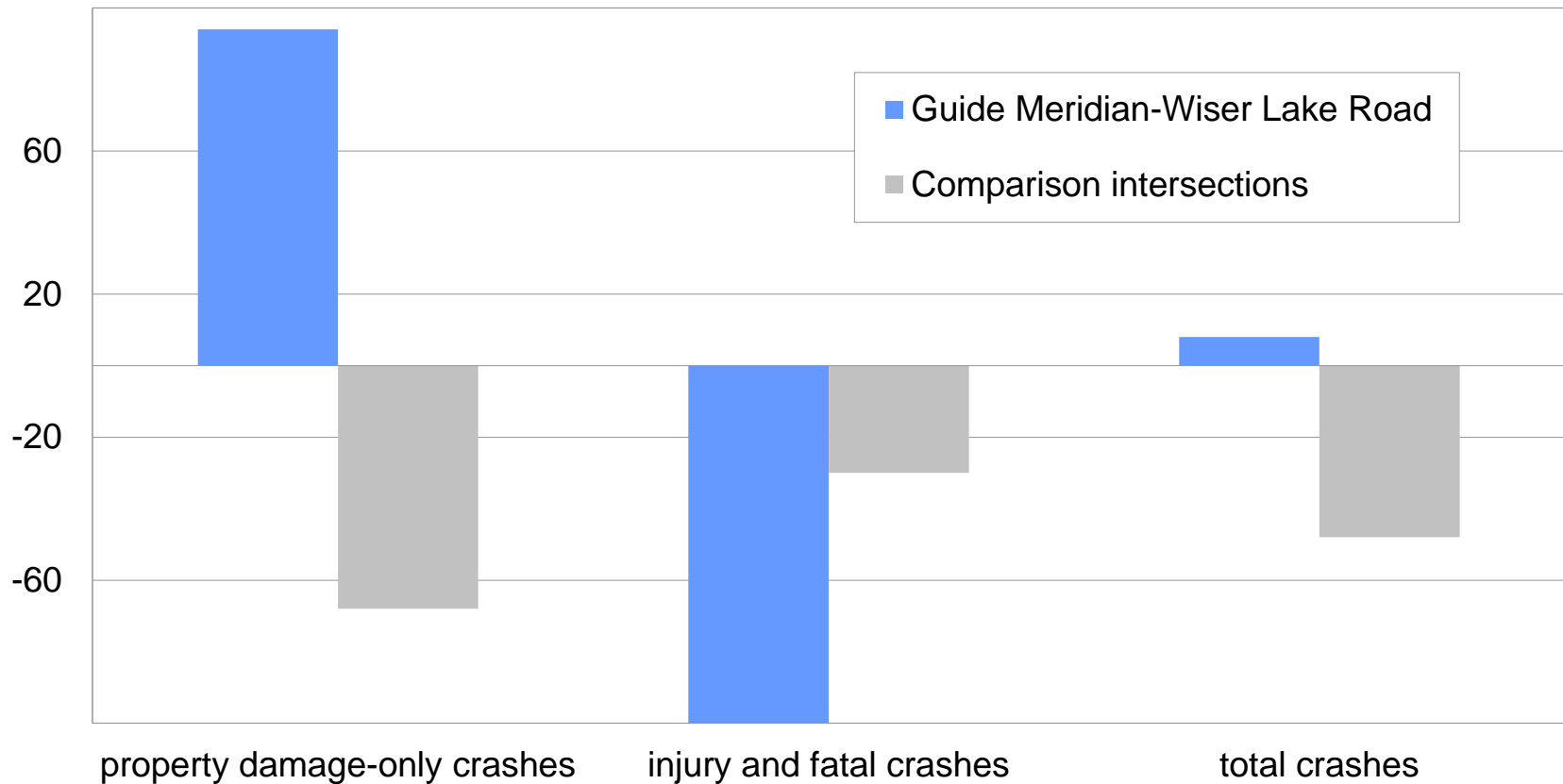


# Percent differences in actual crash rates at Guide Meridian-Pole Road vs. expected rates without roundabout conversion

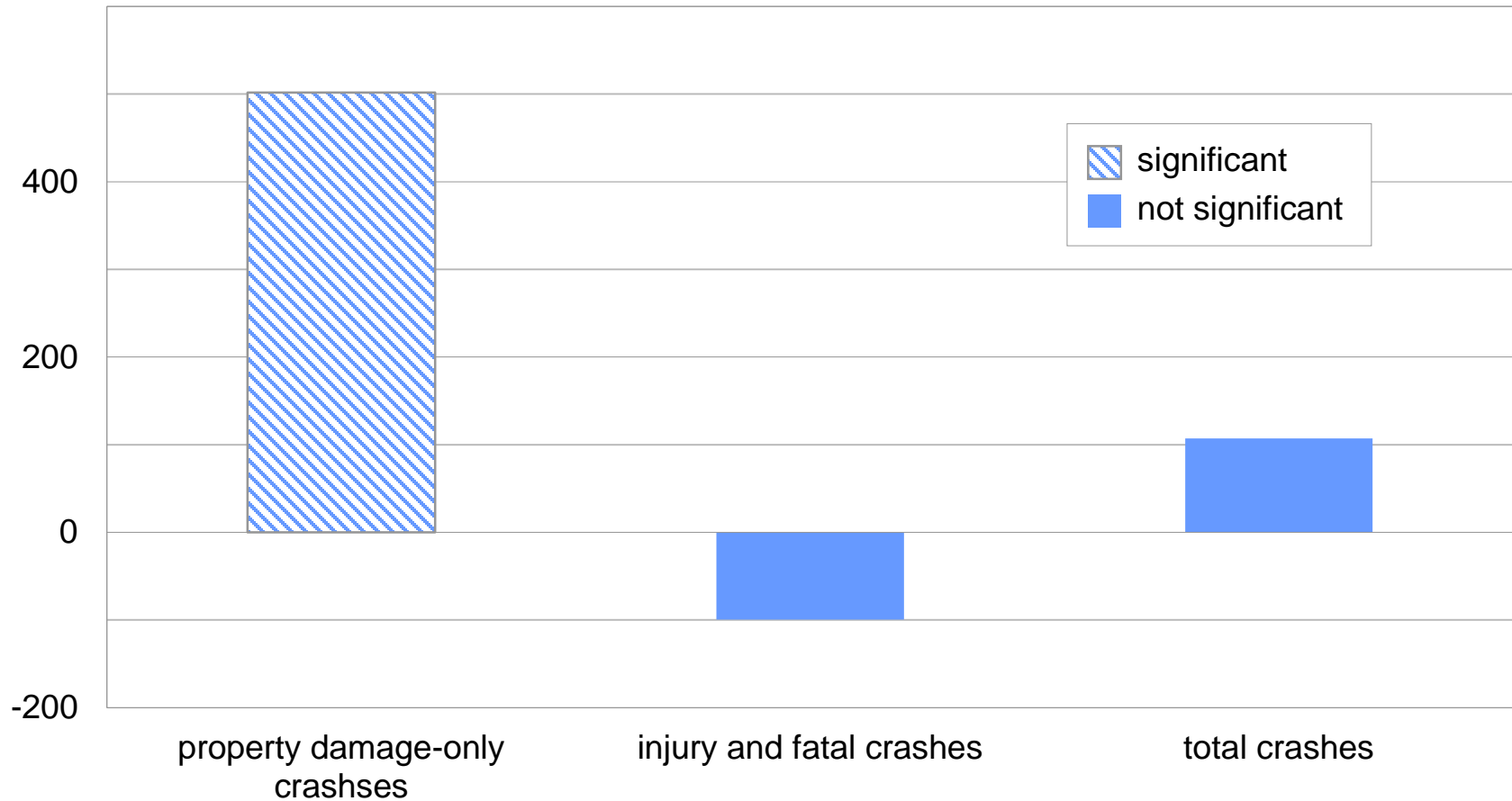


# Percent change in crash rates at Guide Meridian-Wiser Lake Road and comparison intersections

After vs. before roundabout construction



# Percent differences in actual crash rates at Guide Meridian-Wiser Lake Road vs. expected rates without roundabout conversion





# Older driver travel patterns

# Methods

- Drivers photographed before and 4 months after roundabout construction
  - 2 locations along Guide Meridian study corridor
  - 2 comparable locations on Hannegan Road
- Driver age category coded by researchers
  - Younger than 20, 20-59, 60-69, 70 and older
- Odds ratio computed for whether drivers 70 and older were more likely to take Guide Meridian vs. Hannegan Road after the roundabout construction than before

# Proportions of drivers 70 and older on Guide Meridian Road and Hannegan Road

Before and after roundabout construction



- Odds Ratio = 0.32; i.e., odds that older drivers would travel on Guide Meridian vs. Hannegan Road after roundabout construction was 0.32 times lower than before
- Proportions of older drivers were very small (< 5 percent)

# Conclusions

- Drivers' acceptance of roundabouts improved over time
- Substantial benefits in traffic operations and environmental effects
- Serious crash rates declined at roundabouts although not significantly
- Increased complexity of double-lane roundabouts may present challenges
  - Confusion about navigating roundabouts persisted one year after
  - Some older drivers may be taking an alternative route to avoid roundabouts
  - Property damage-only and total crash rates increased
- Relatively short-term effects of roundabout conversions examined
- When roundabouts are part of a larger effort to increase capacity on a roadway, effects on traffic performance, emissions, and even safety may accrue some years after construction



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