

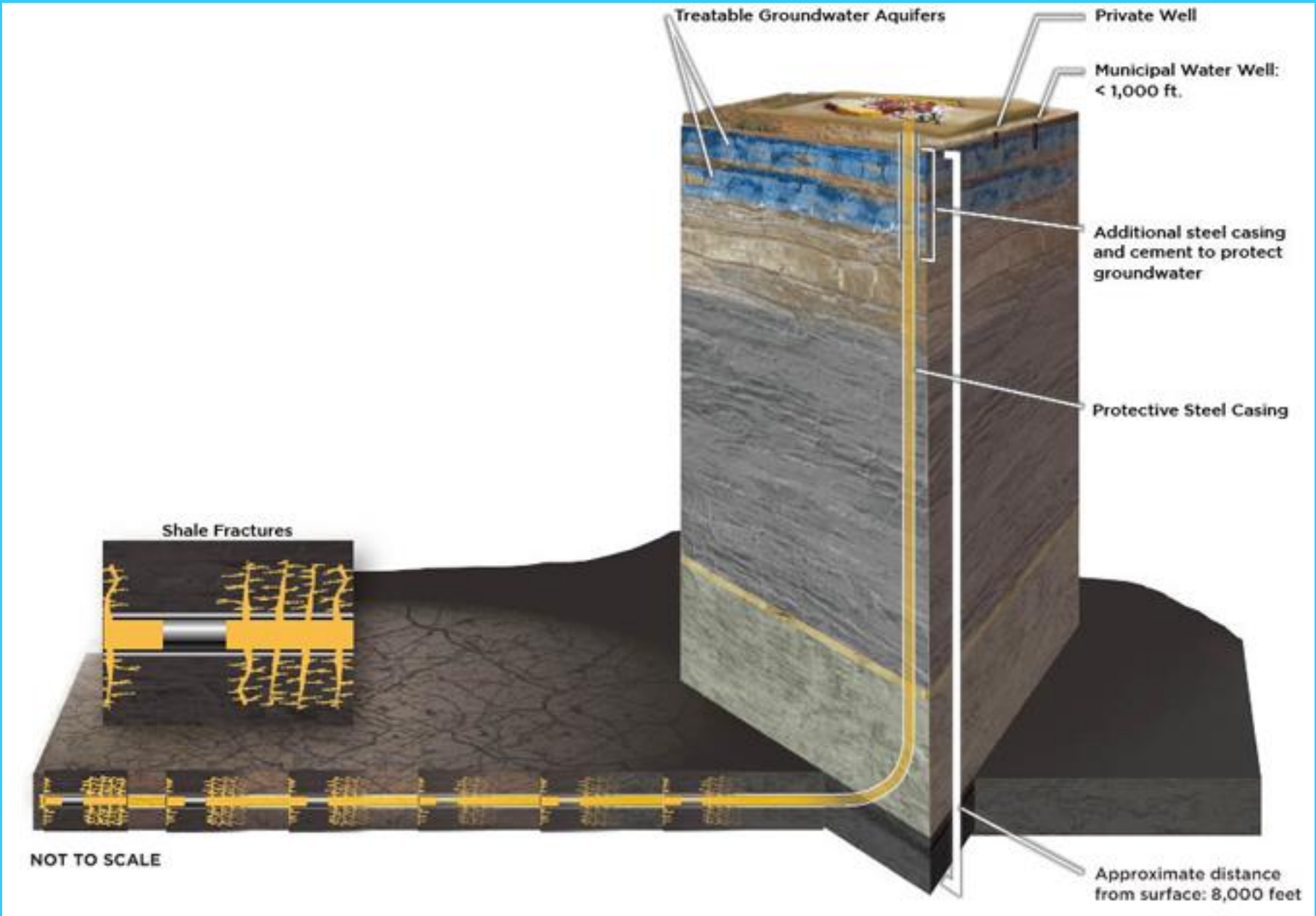


An overview of trends within hydraulic fracturing in Louisiana with a focus on Haynesville Gas Play

Douglas Carlson
Louisiana Geological Survey

12 th Annual Louisiana Water Conference,
March 27, 2018 Baton Rouge, Louisiana

1. Trends of water volume used for hydraulic fracturing
2. Trends in concentration of compounds used in hydraulic fracturing
3. Summary
4. Implications of trends for next gas boom



Chesapeake Energy Inc. (not dated)

Look at trends of hydraulic fracturing volumes by:

FracFocus

Haynesville

Other units

LA DNR

Haynesville

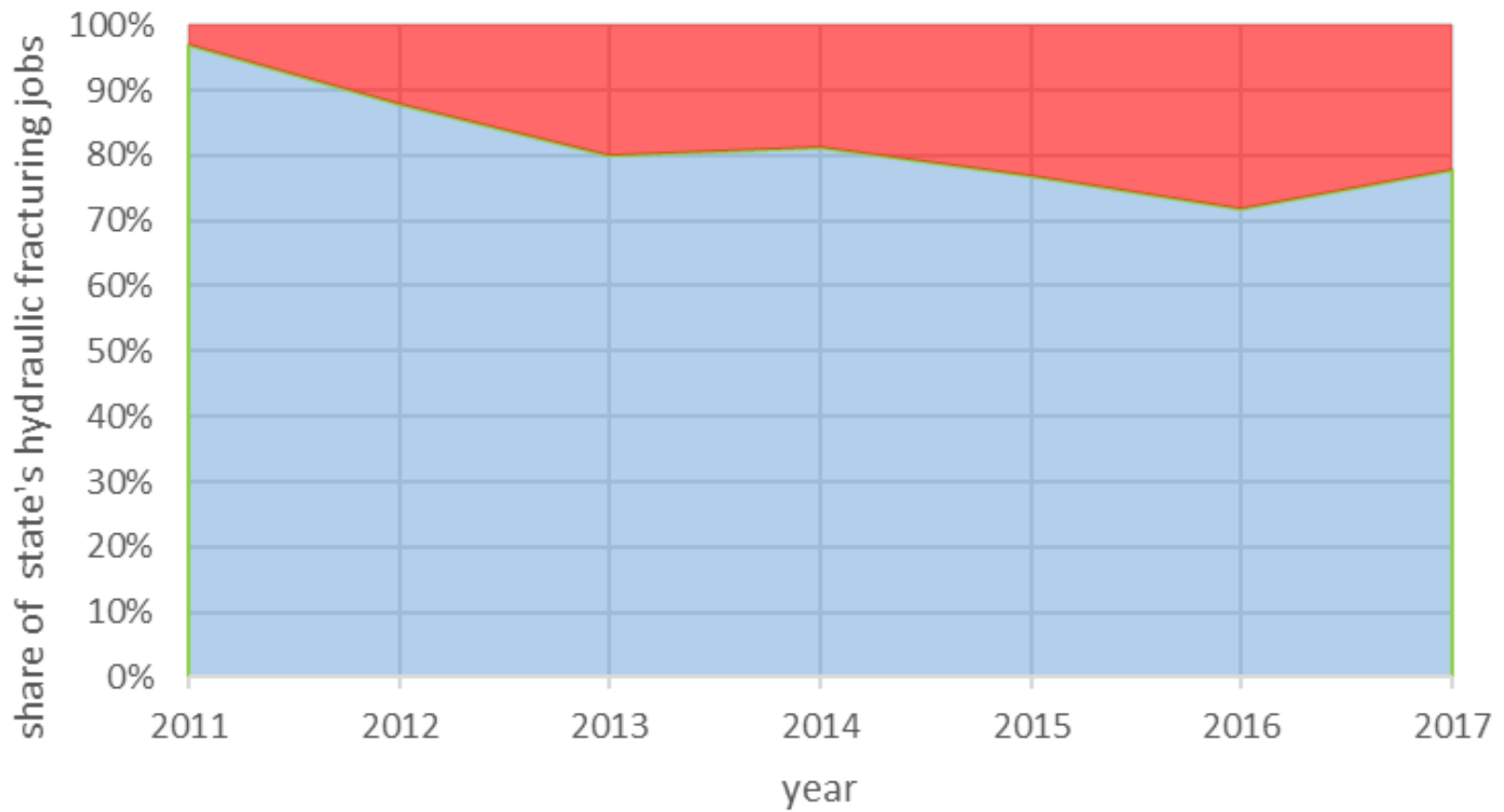
Cotton Valley

Hosston

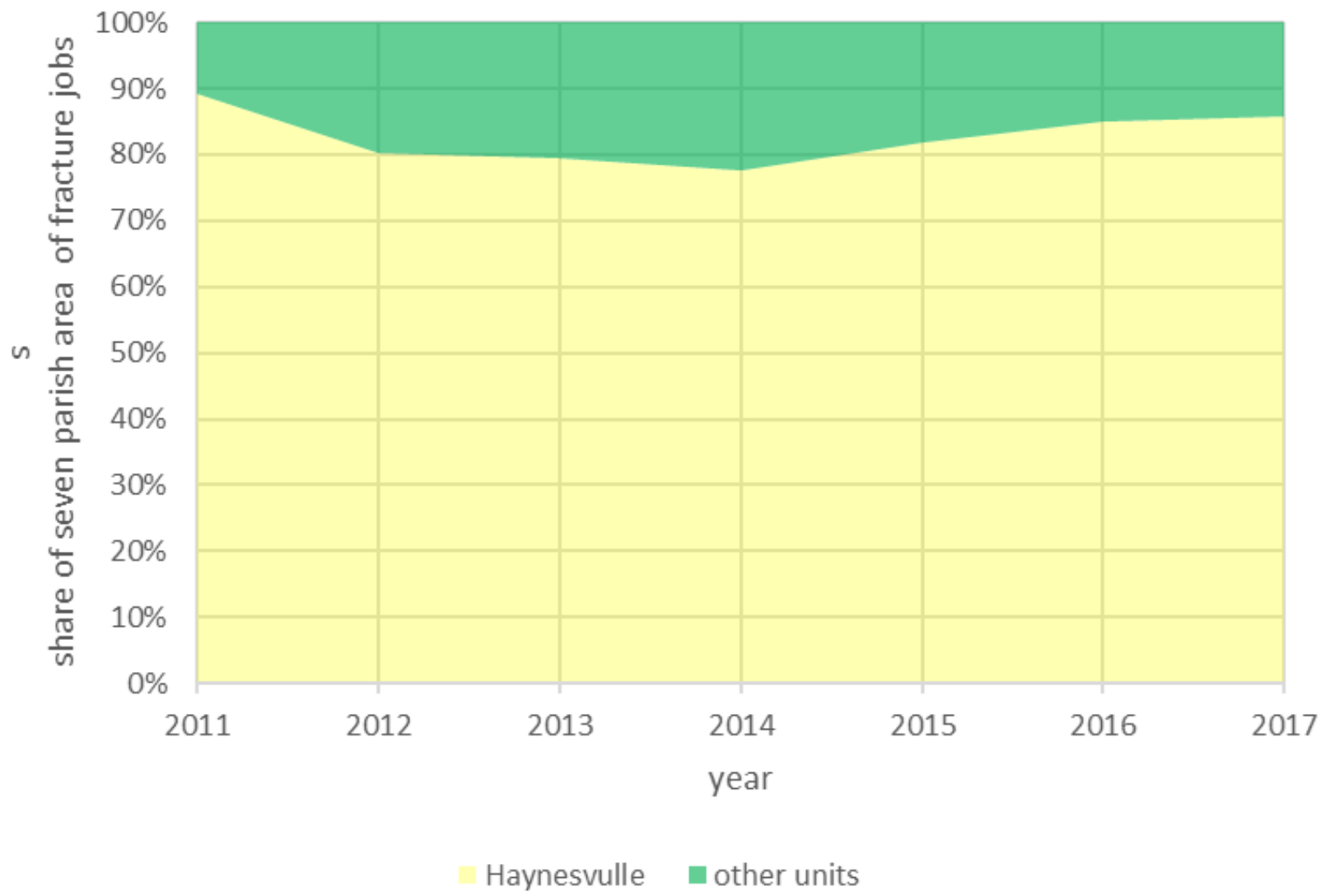
Wilcox

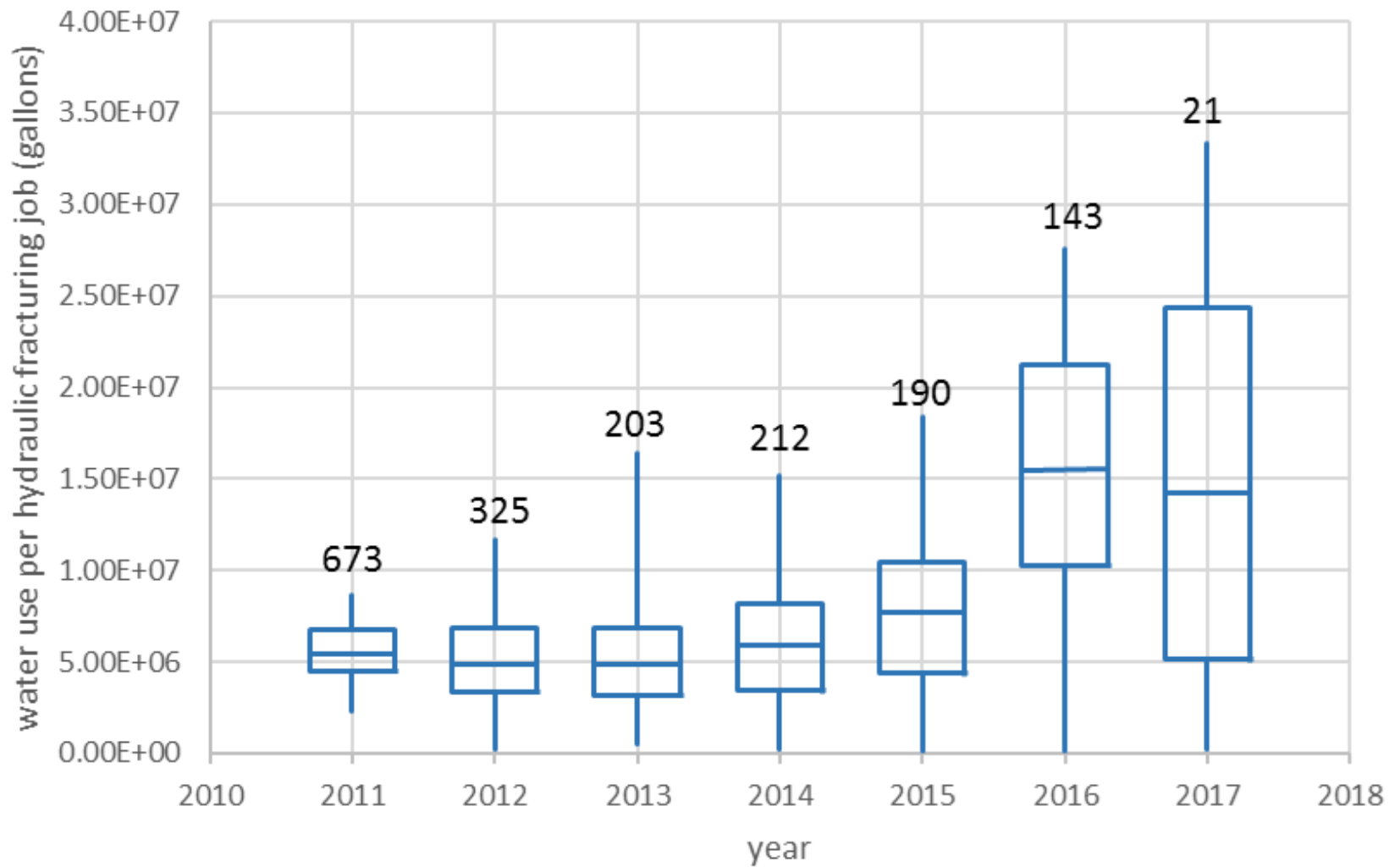
Initial fracturing

Re-fracturing

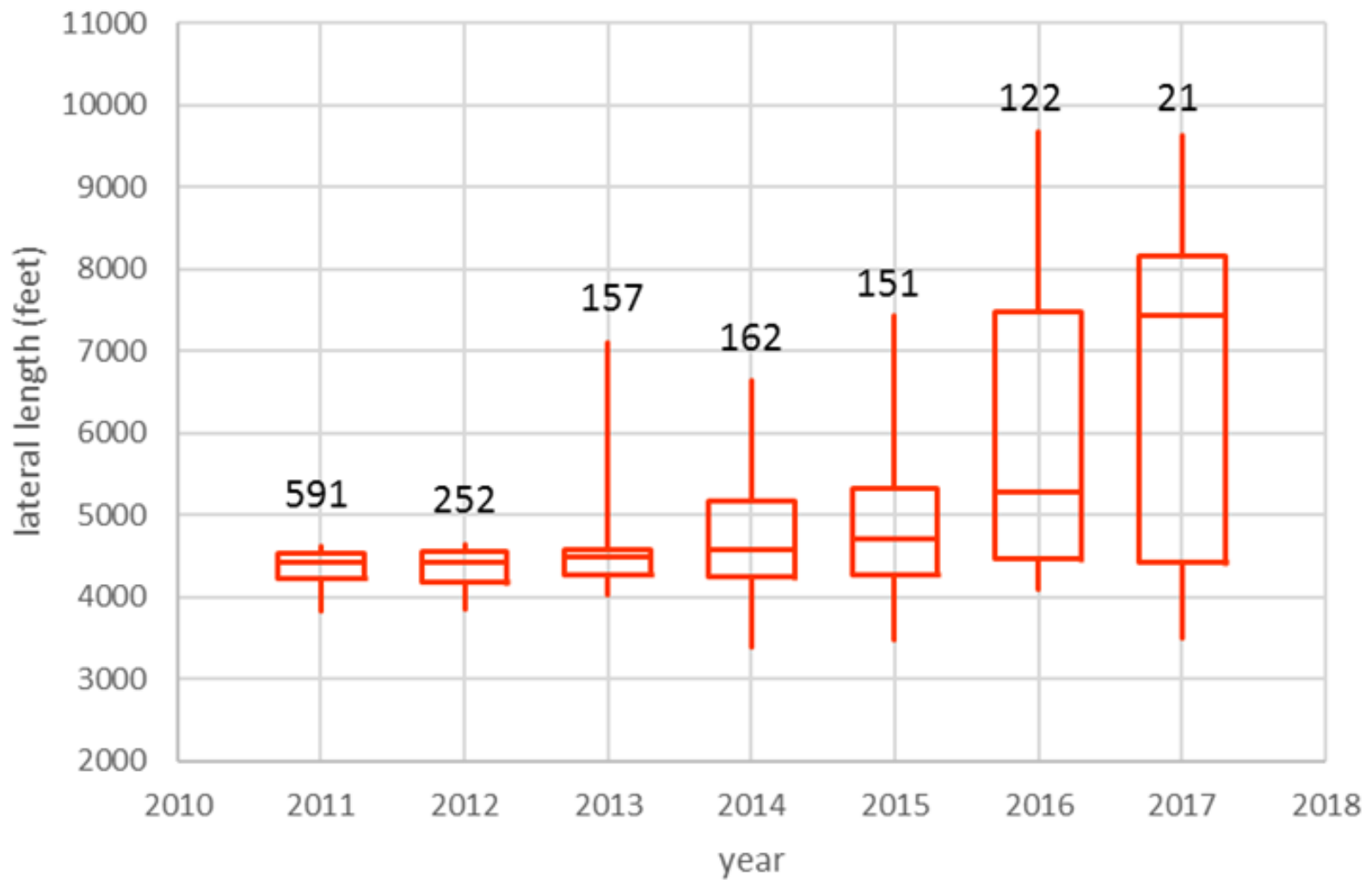


■ NW LA ■ rest of LA

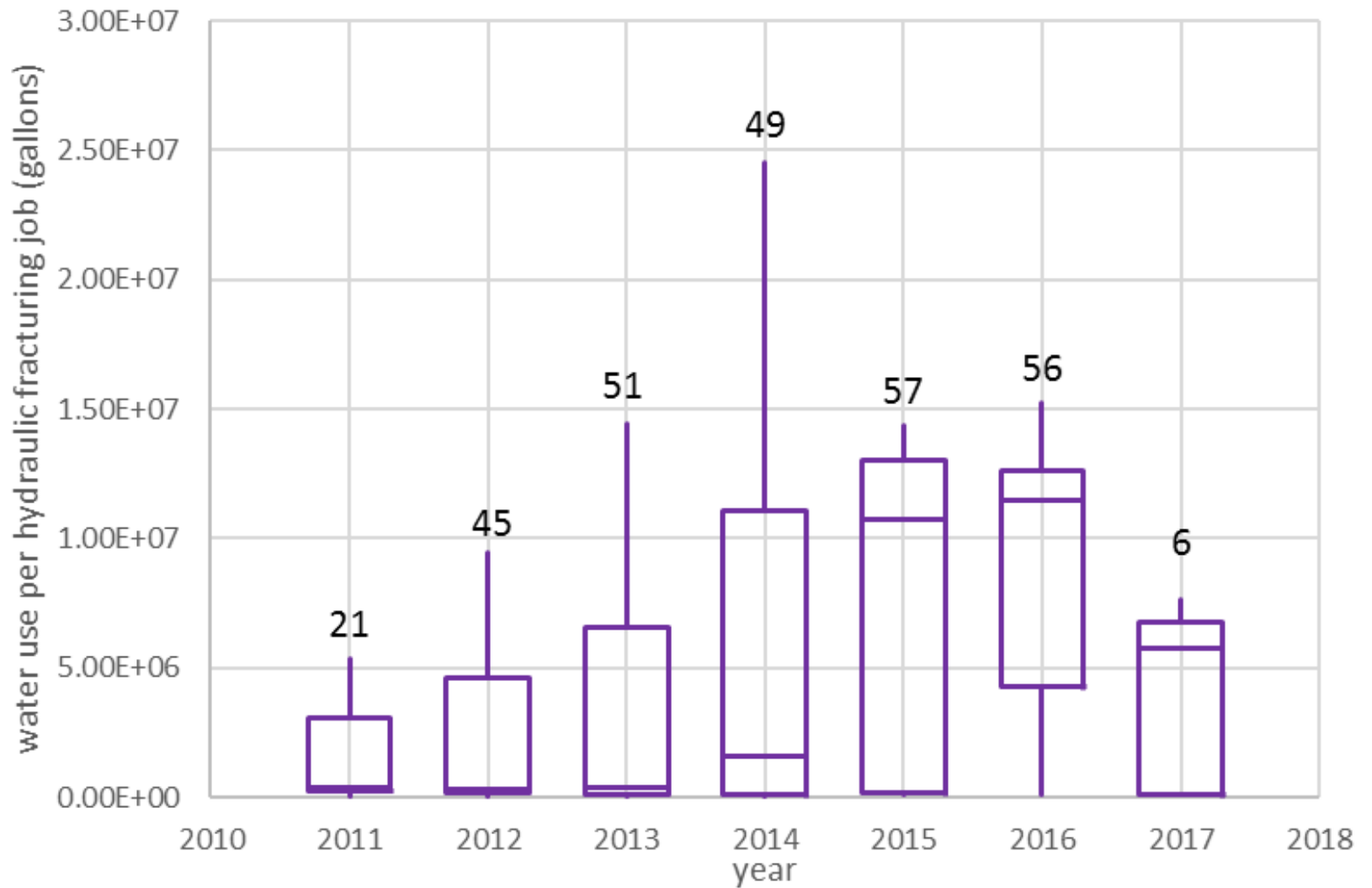




Haynesville

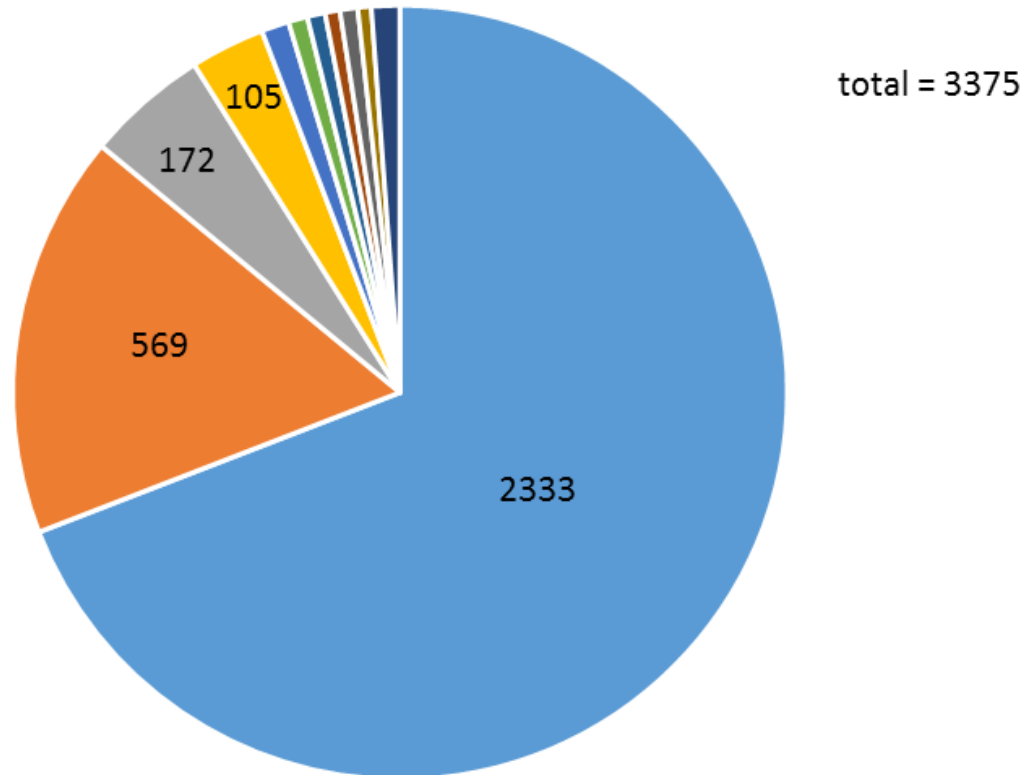


Haynesville



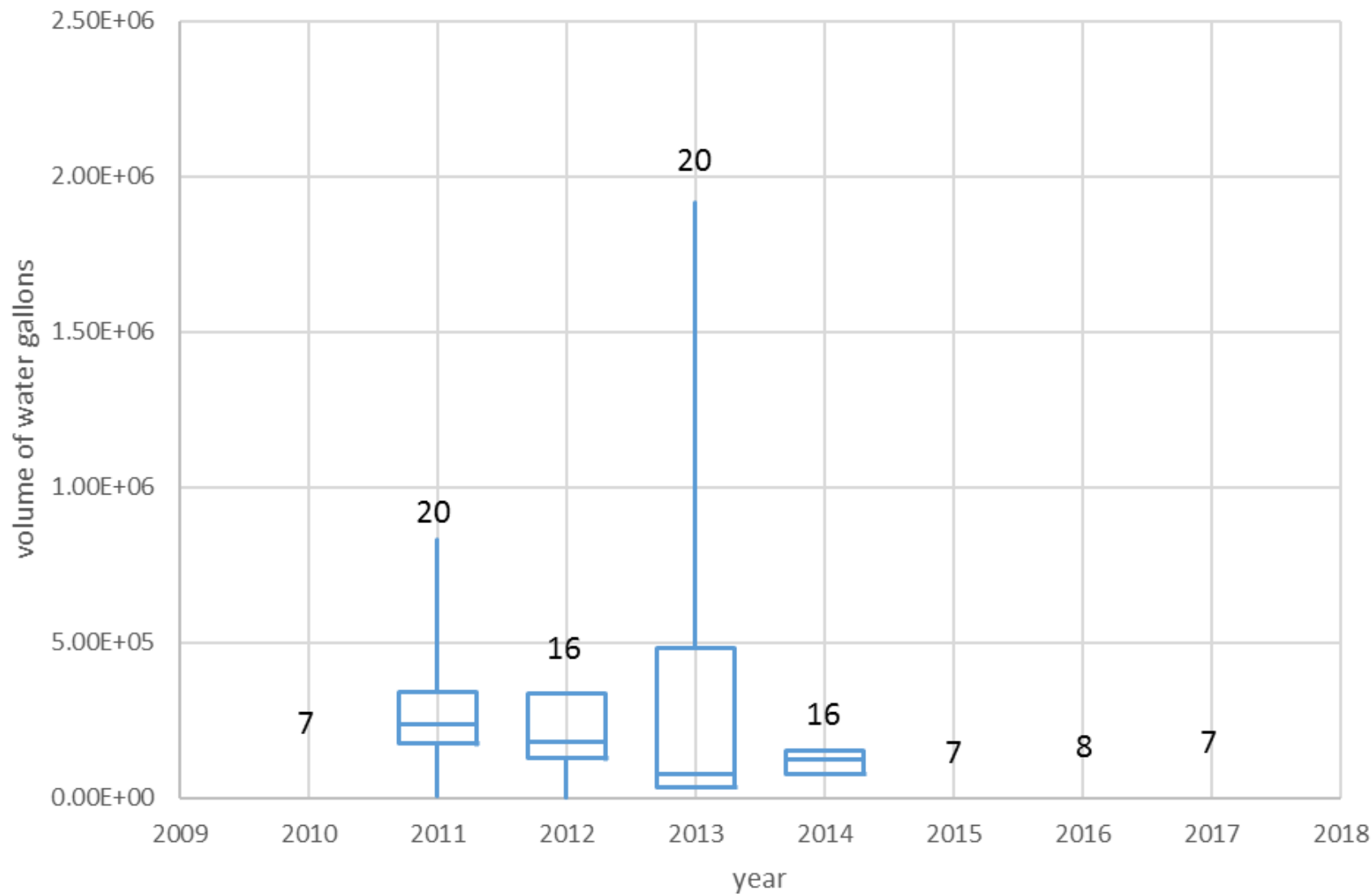
Other units

Number of Hydraulic Fracturing Jobs 2009 to 2018

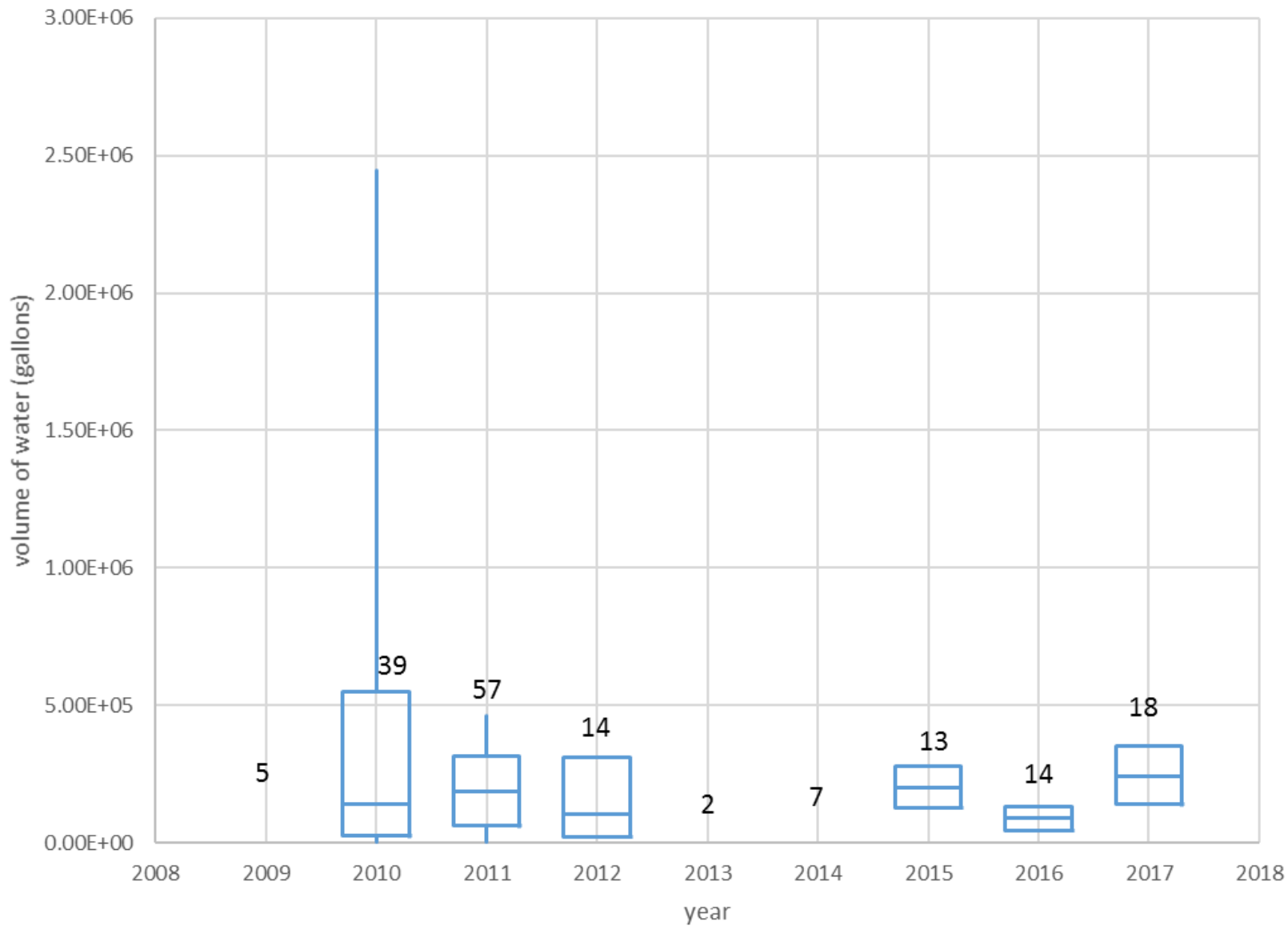


- Haynesville Formation
- Cotton Valley Group
- Hosston Formation
- Wilcox Group
- Nacatoch Formation
- Smackover Formation
- Pliocene sands
- Tuscaloosa Group
- Micoene sands
- Cockfield Formation
- other

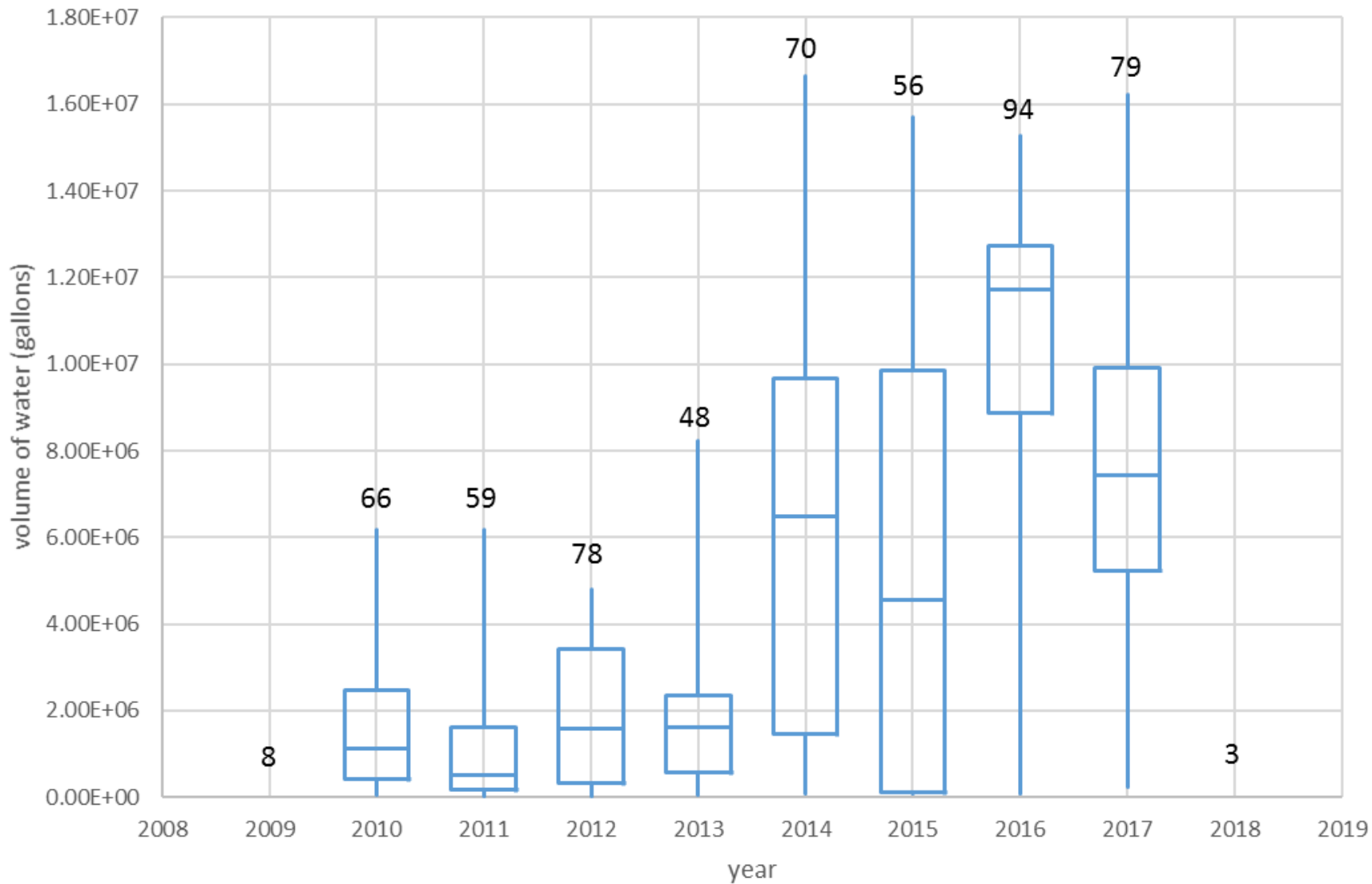
Distribution of hydraulic fracturing jobs by geologic unit



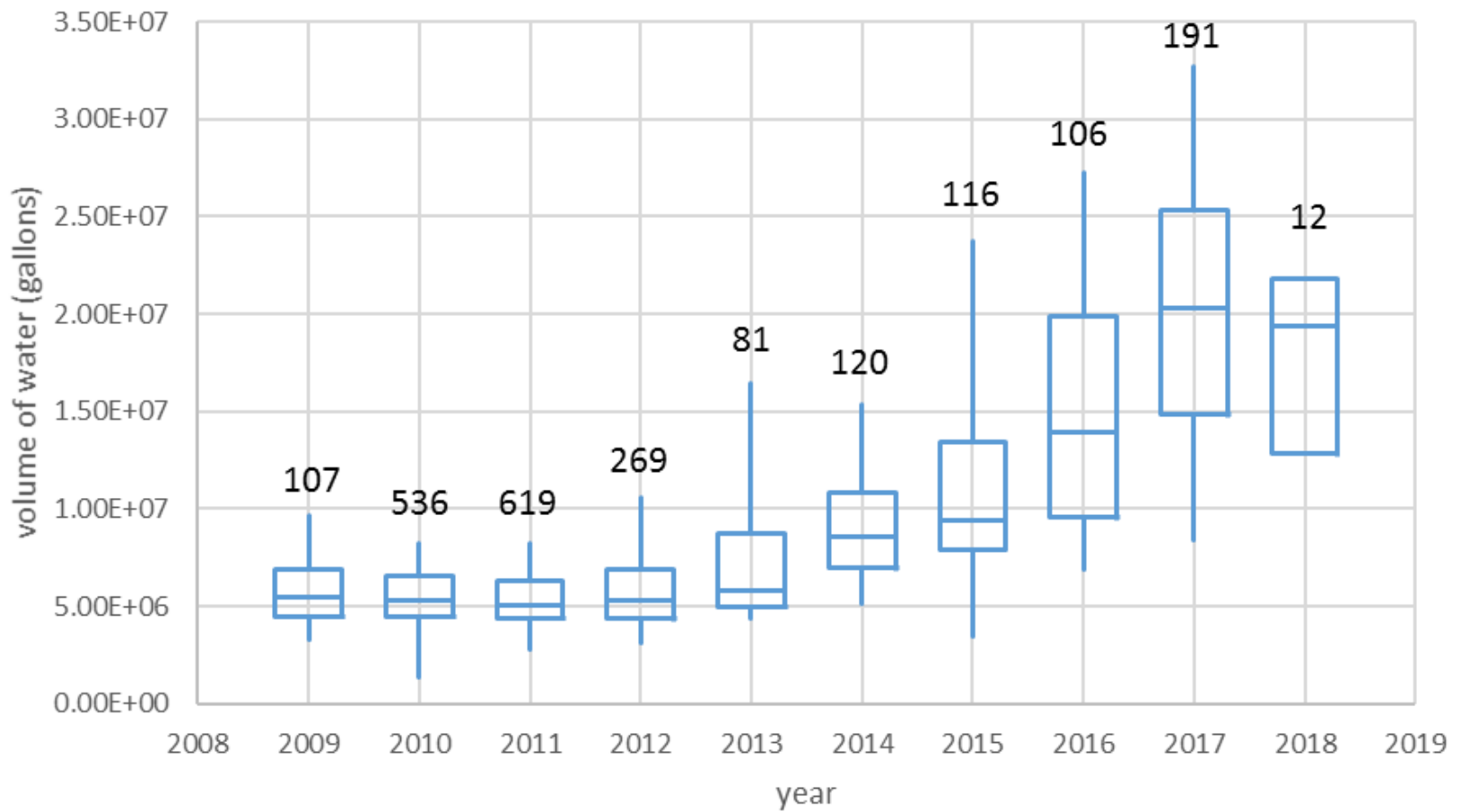
Hydraulic fracturing in Wilcox Group



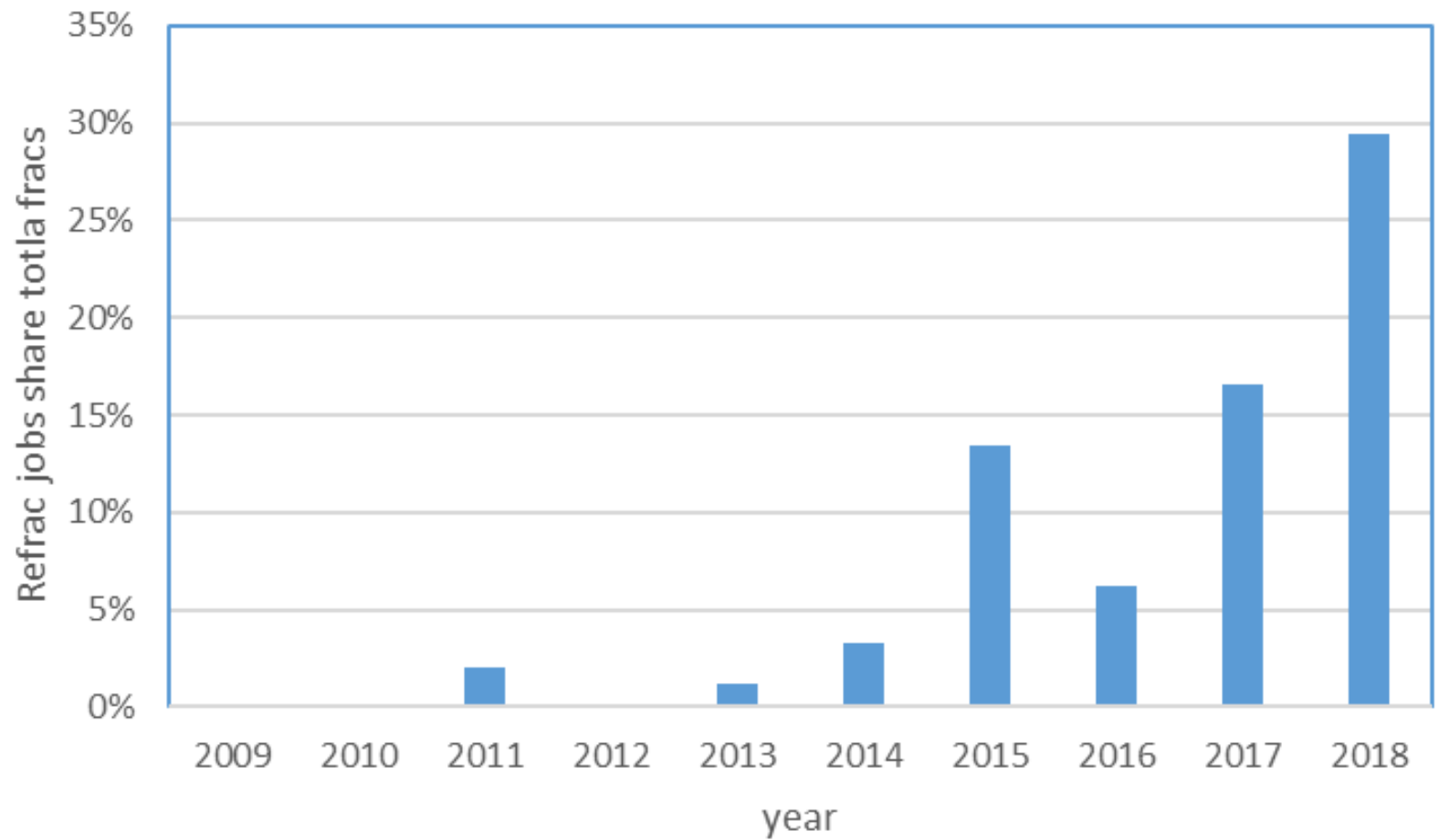
Hydraulic fracturing in Hosston Formation



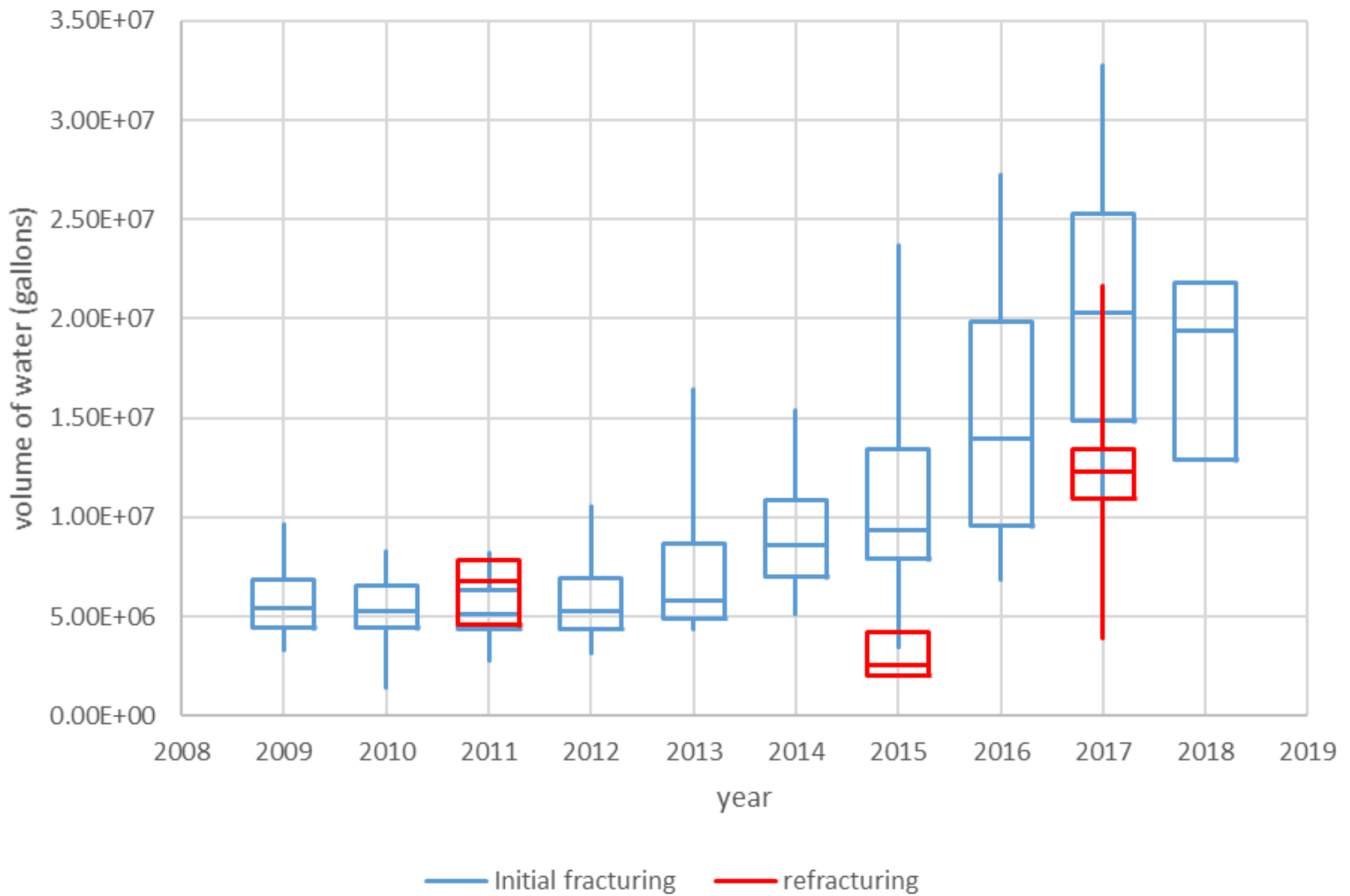
Cotton Valley Group, mainly lower Cotton Valley



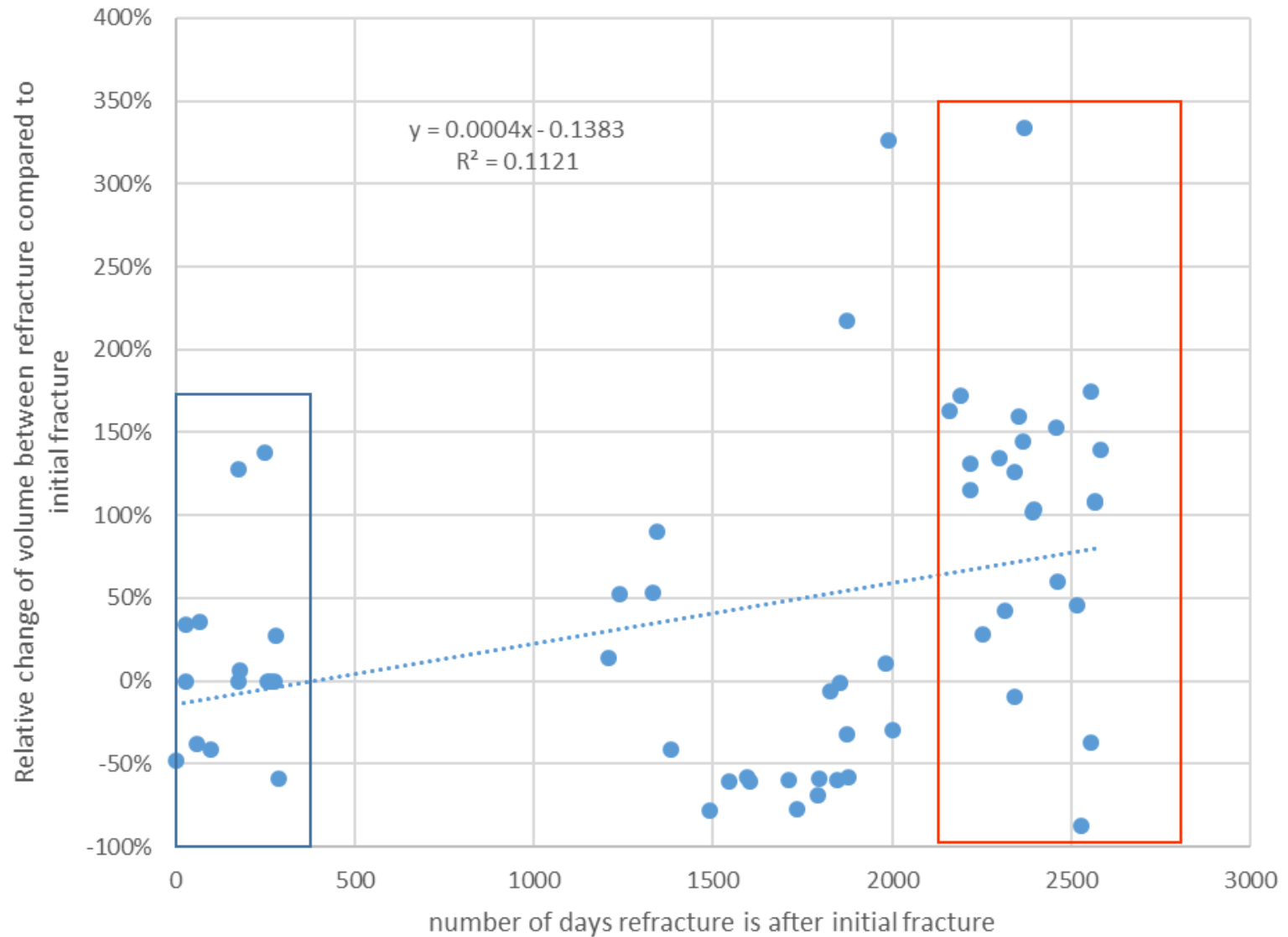
Haynesville results for initial fracturing



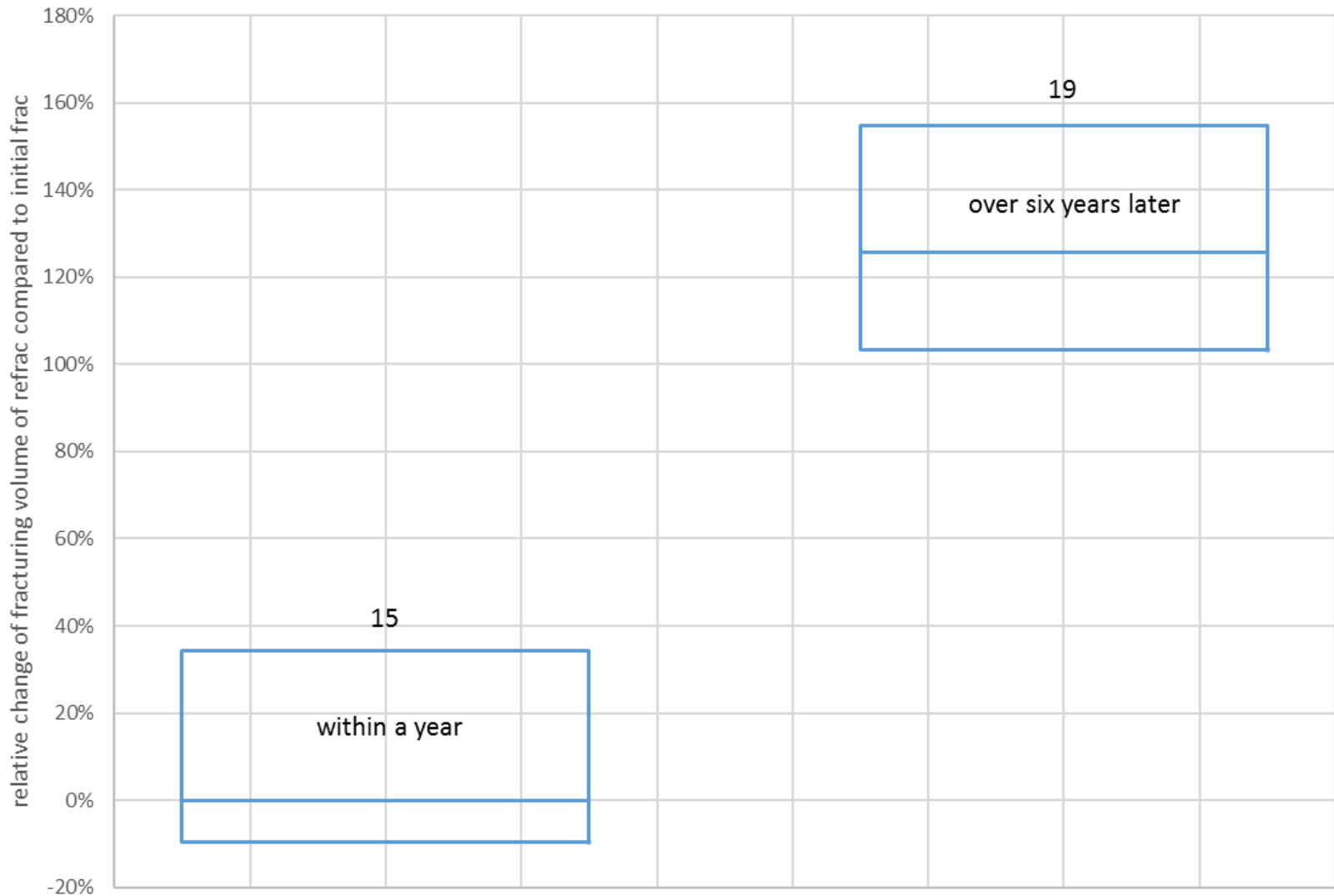
Share of fracturing jobs that is re-fracturing



Size of re-fracturing job compared relative to Initial fracturing job

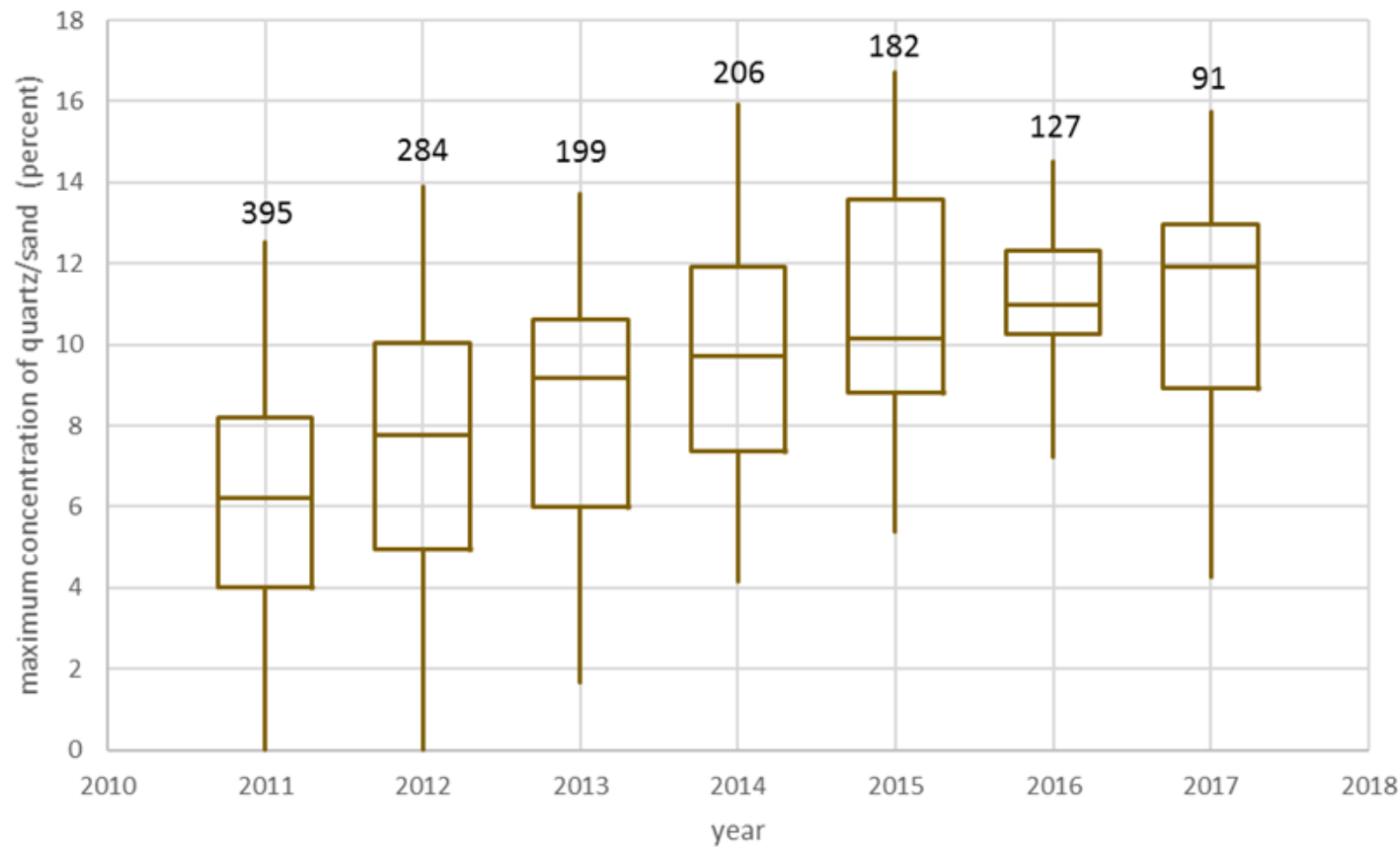


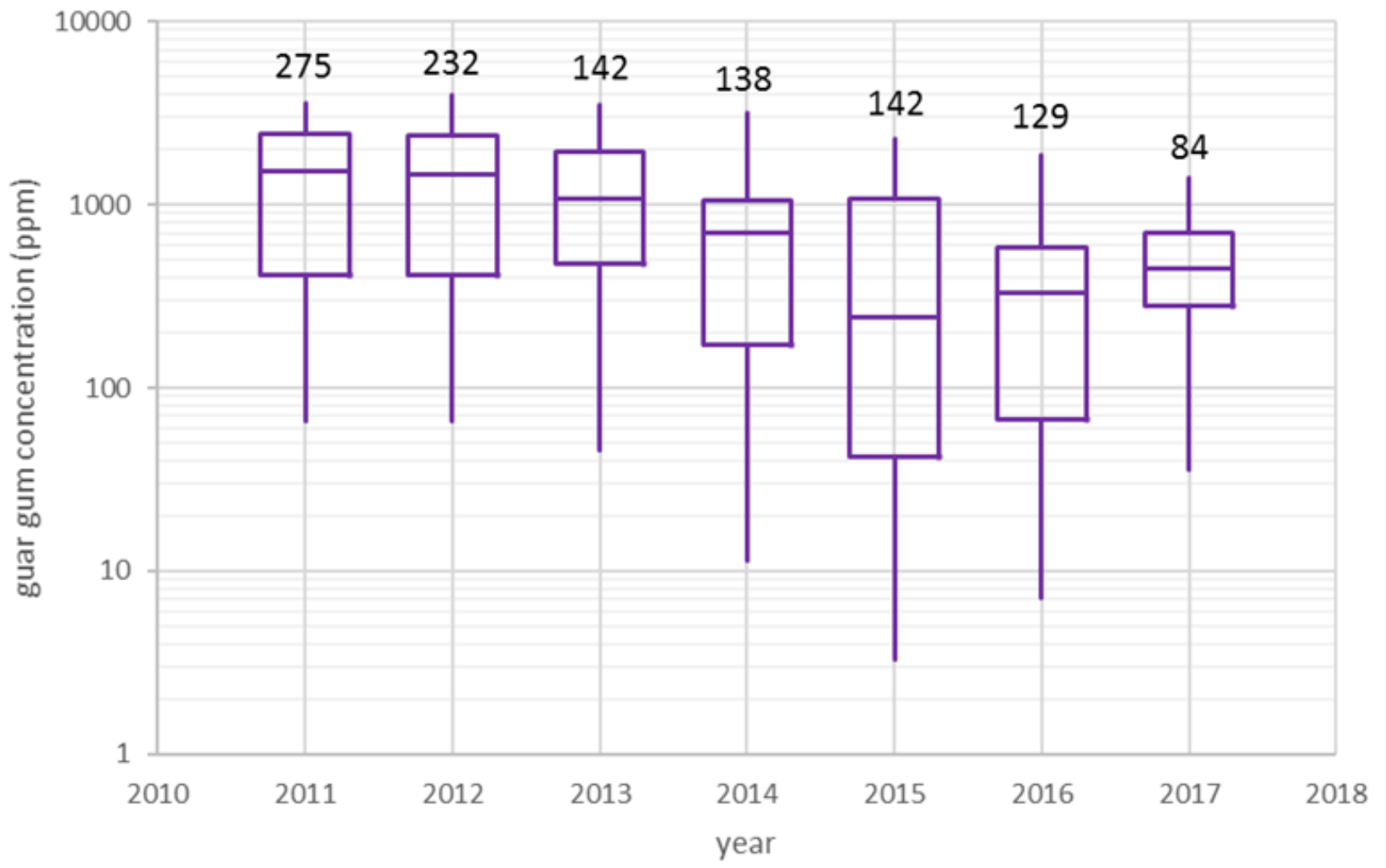
Relative size of re-fracturing volume compared to initial fracturing volume for a single well as function of days between the two fracture events



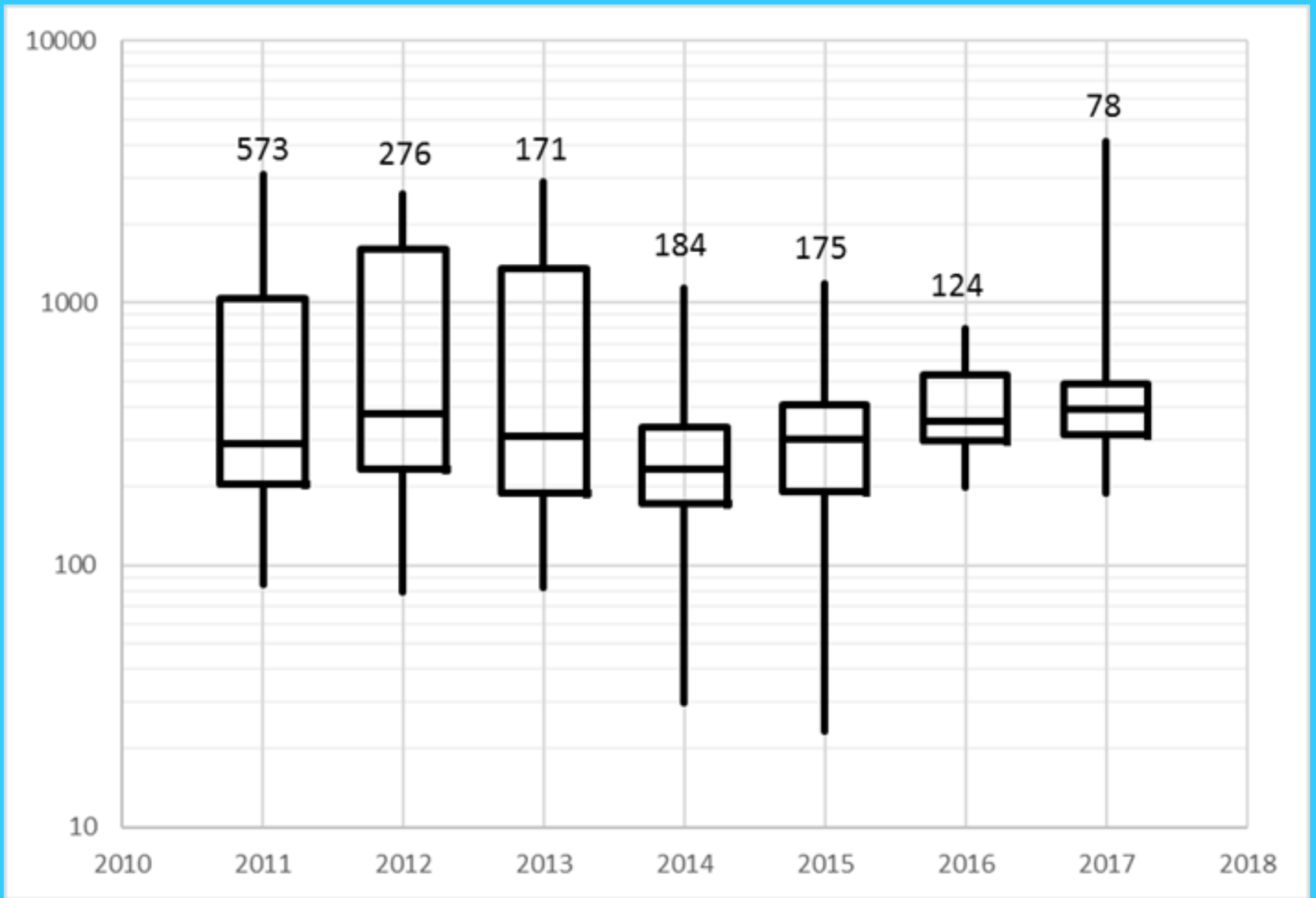
Comparison of volume of water used for re-fracture to initial fracture for early and recent re-fracturing comparisons

Product Function	Chemical Purpose	Chemical commonly used in Louisiana
Biocide	Eliminates bacteria	Glutaraldehyde
Breaker	Delays gel break down	Ammonium Persulfate, and Sodium Chloride (4)
Clay Stabilizer	Prevents clays from swelling or shifting	Sodium Chloride (4)
Corrosion Inhibitor	stabilizer agent, prevents the corrosion	Isopropanol (5), Methanol (2), and Formic Acid
Crosslinker	Maintains fluid viscosity as temperature increases, product stabilizer	Hydrotreated Light Petroleum Distillate (1), Ethylene Glycol (8), and Methanol (2)
Friction Reducer	Carrier fluid, Friction Reducer, Product stabilizer	Hydrotreated Light Petroleum Distillate (1), Methanol (2), and Ethylene Glycol (8)
Gelling Agent	Thickens solution to suspend the sand, Carrier for guar gum, stabilizer	Guar Gum (3), Hydrotreated Light Petroleum Distillate (1), Methanol (2), and Ethylene Glycol (8)
Iron Control	Prevents precipitation of metal oxides	Citric Acid, and Acetic Acid,
Non-Emulsifier	Product stabilizer	Isopropanol (5), and Ethylene Glycol (8)
pH Adjusting Agent	to maintains the effectiveness of other components	Sodium Hydroxide (6); Potassium Hydroxide (7), and Acetic Acid,
Scale Inhibitor	Prevents scale deposits in the pipe	
Surfactant	increase the viscosity of the fracture fluid, stabilize, and carry active surfactant ingredients	Ethanol (9), Naphthalene, Methanol (2), Isopropyl Alcohol/Isopropanol (5), and 2-Butoxyethanol

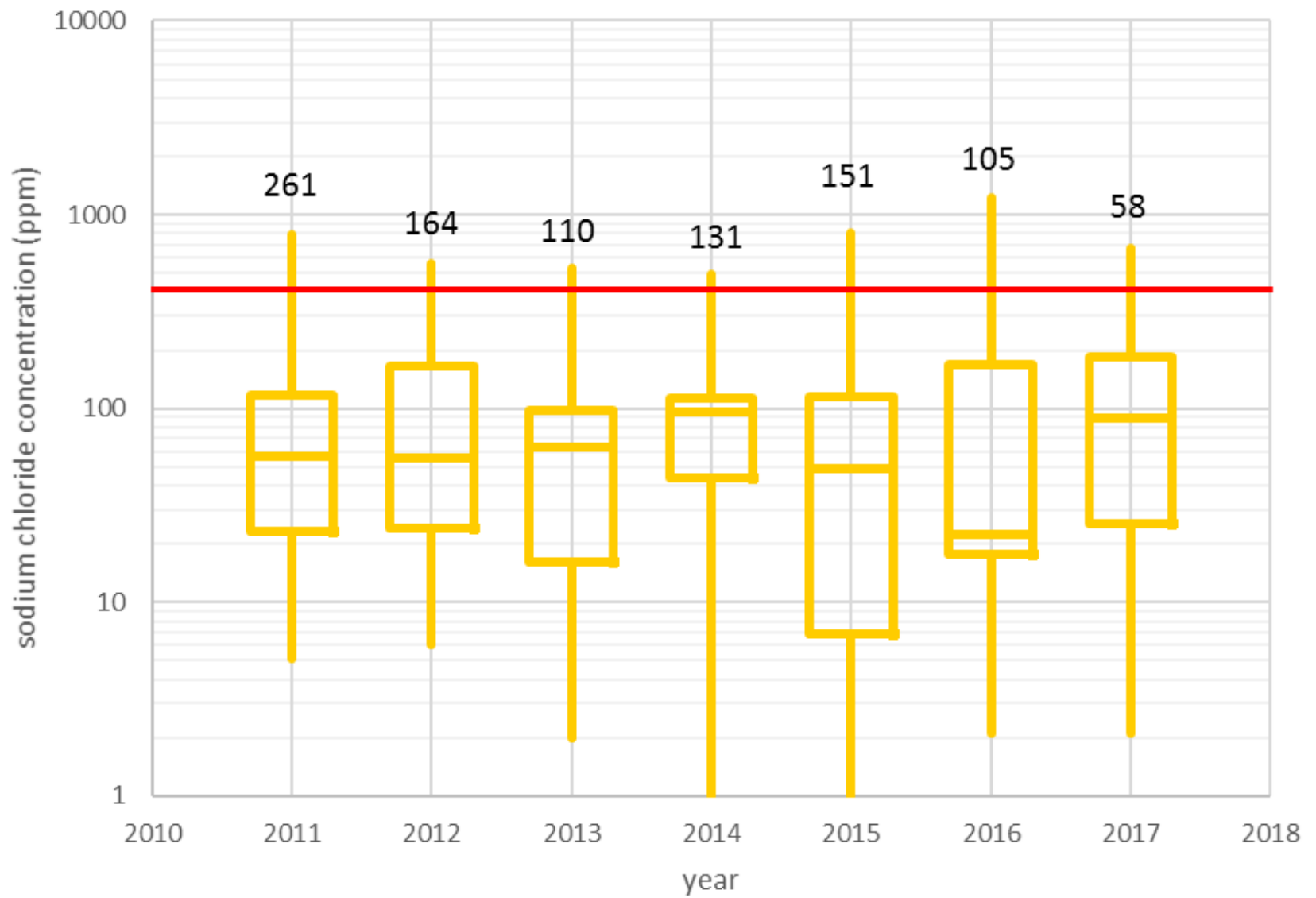




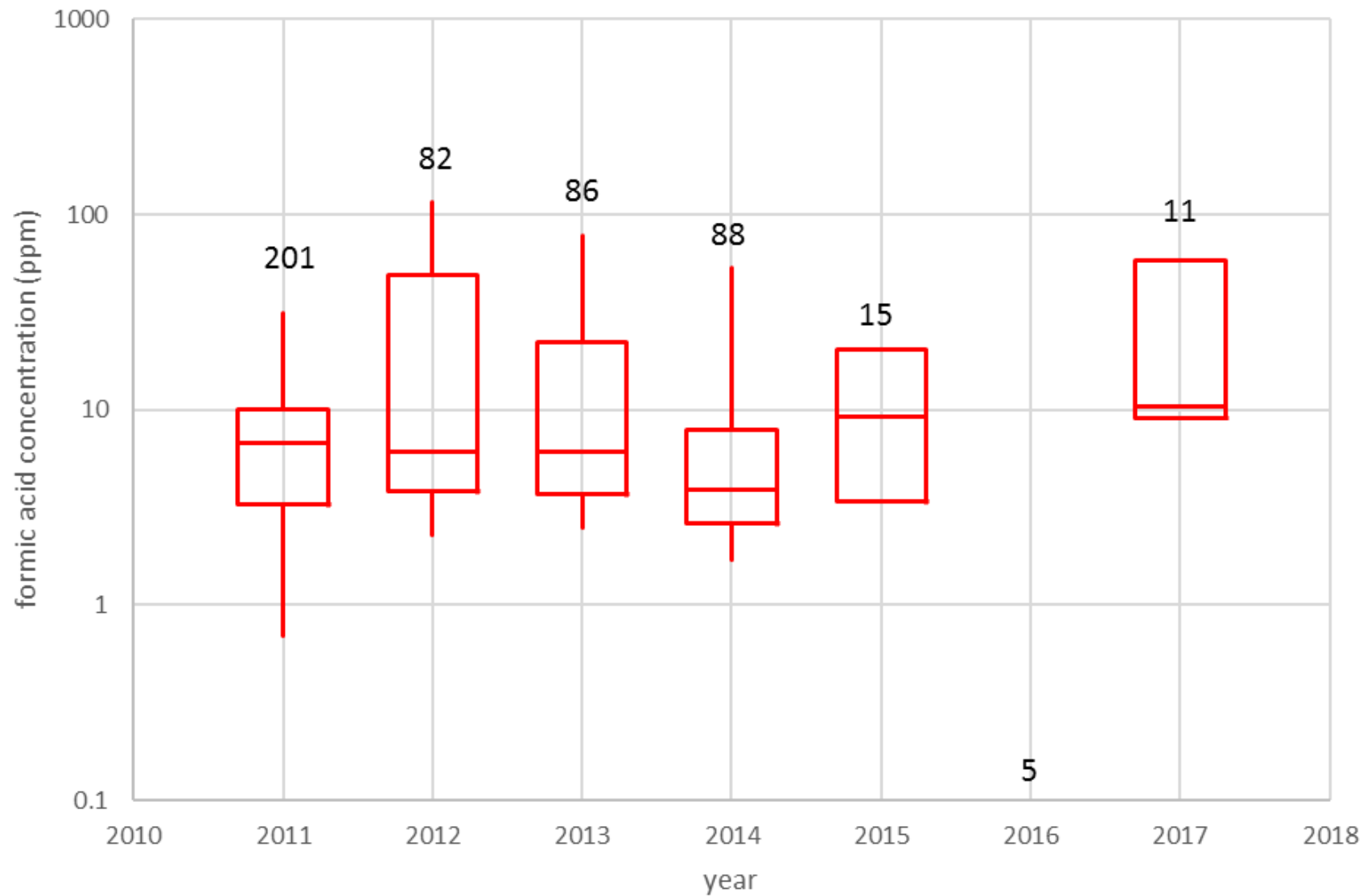
Maximum concentration of guar gum



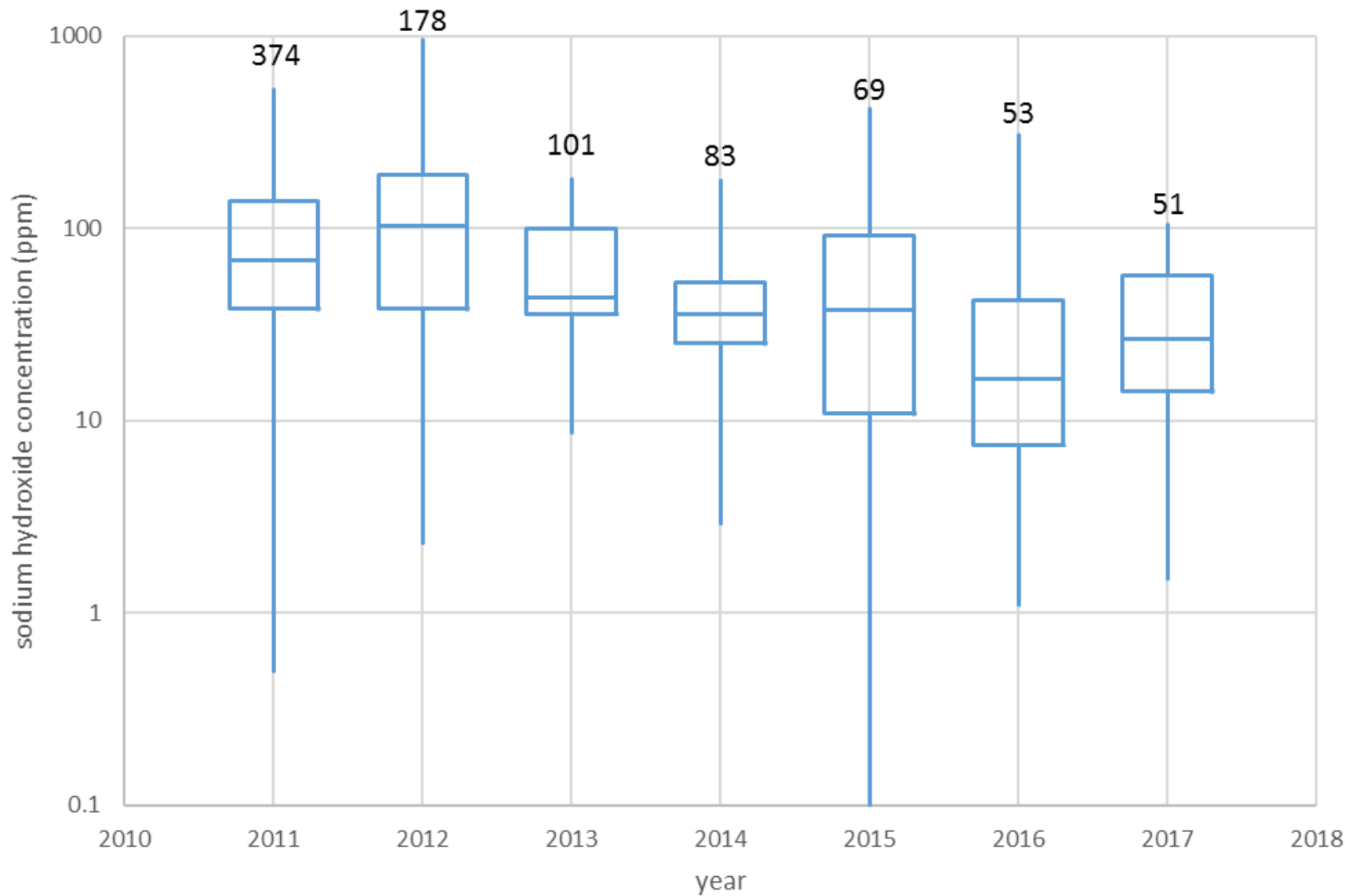
Maximum concentration of petroleum distillates/kerosene/mineral spirits



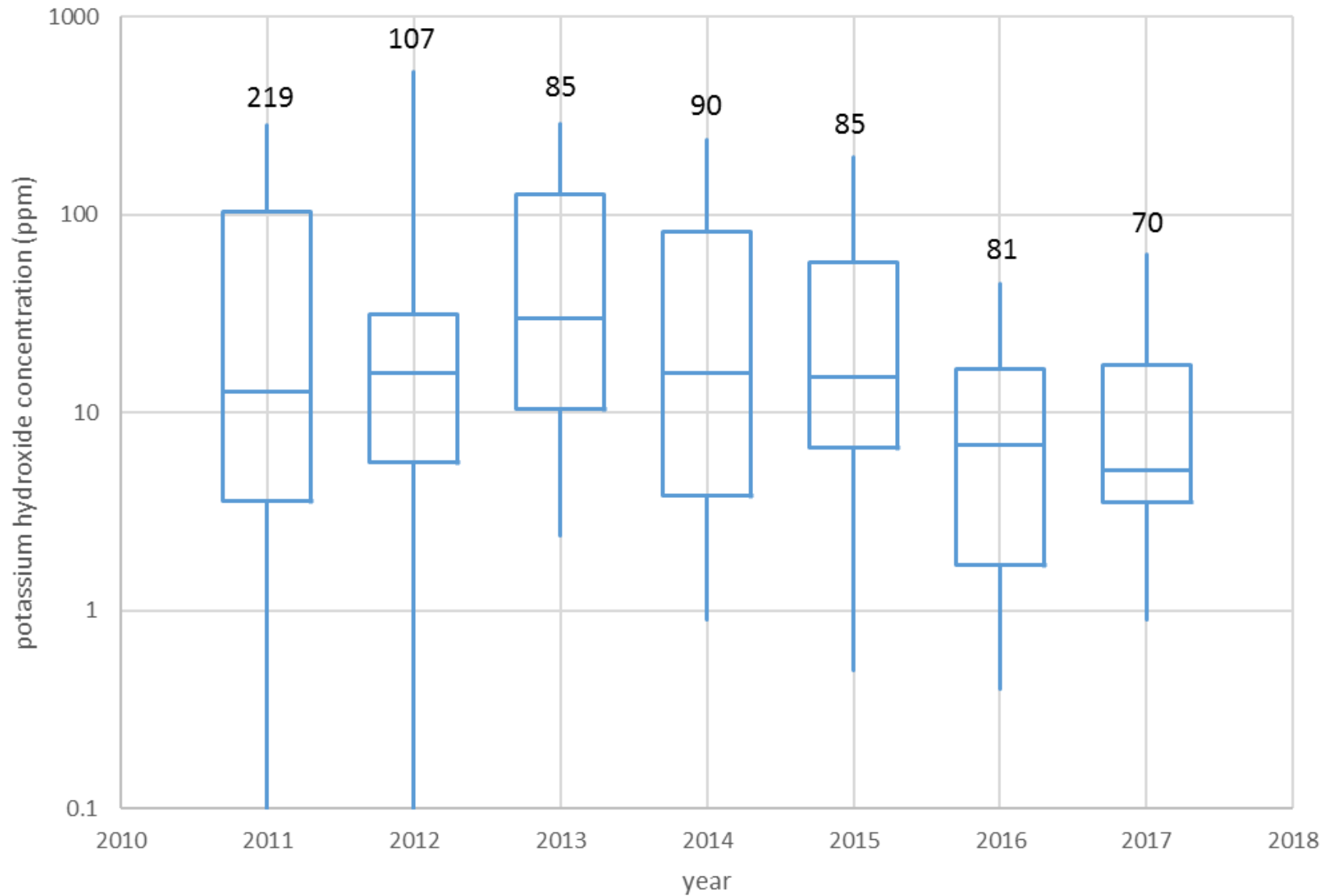
Maximum concentration of sodium chloride/table salt



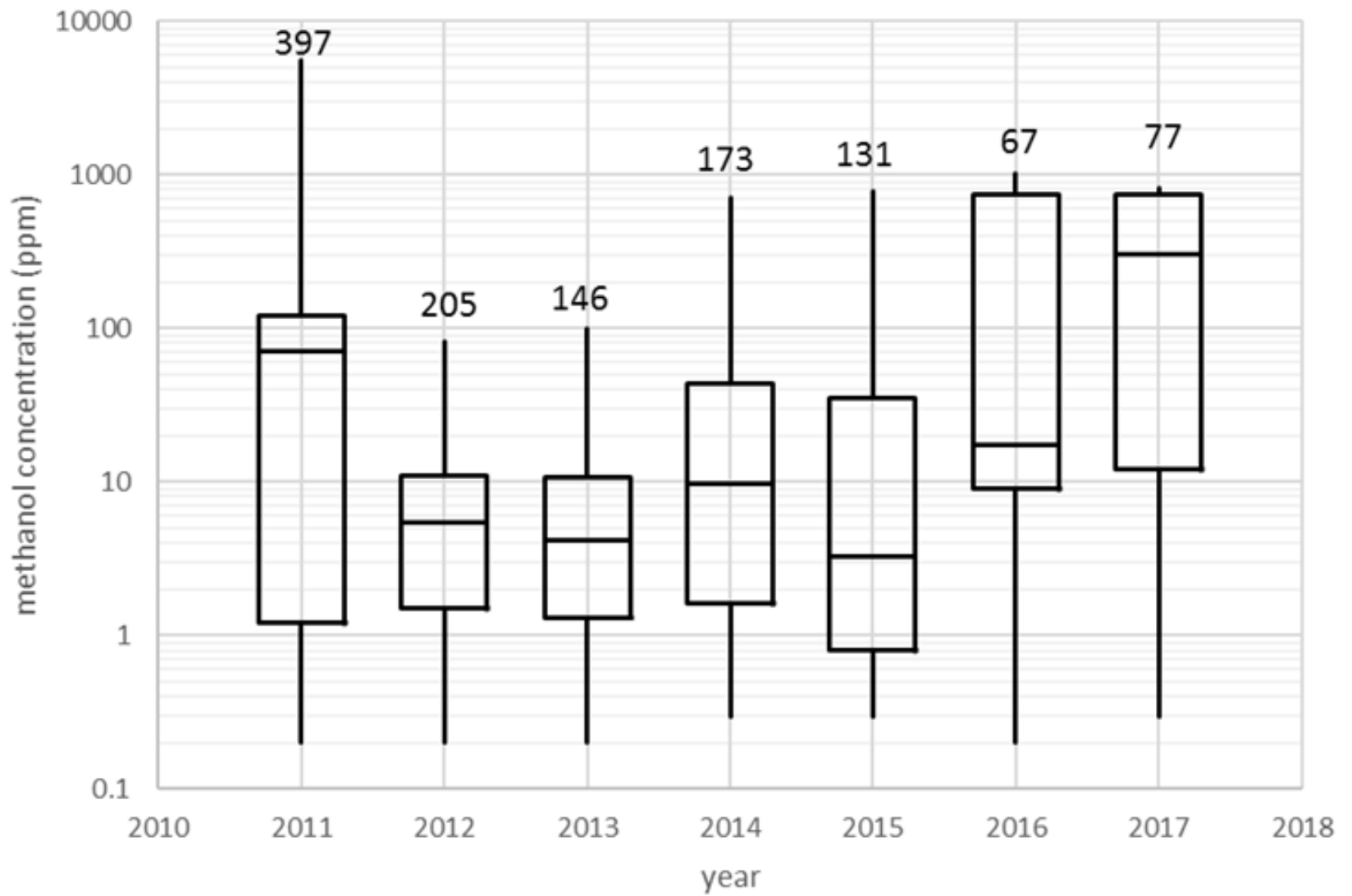
Maximum concentration of formic acid



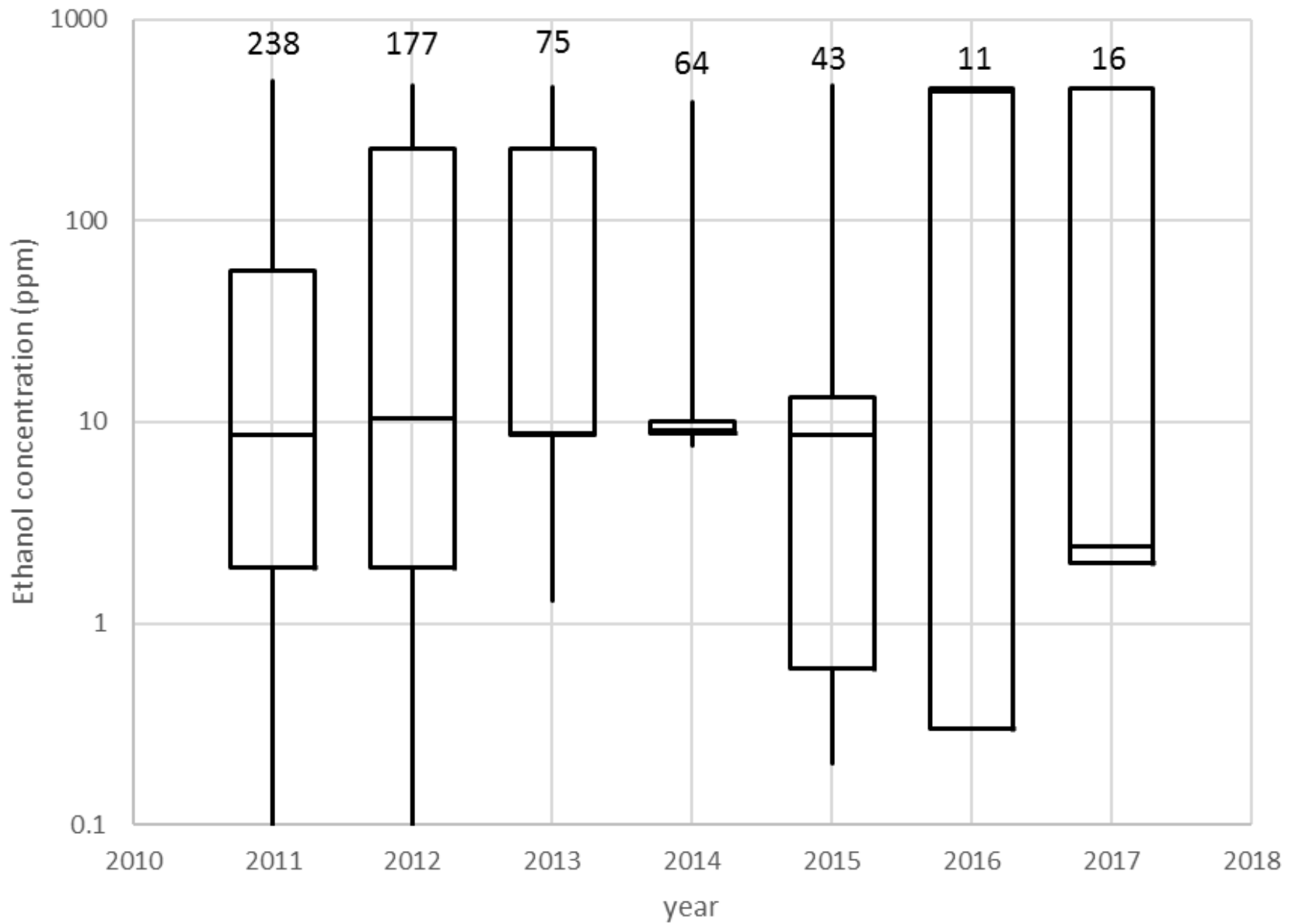
Maximum concentration of sodium hydroxide



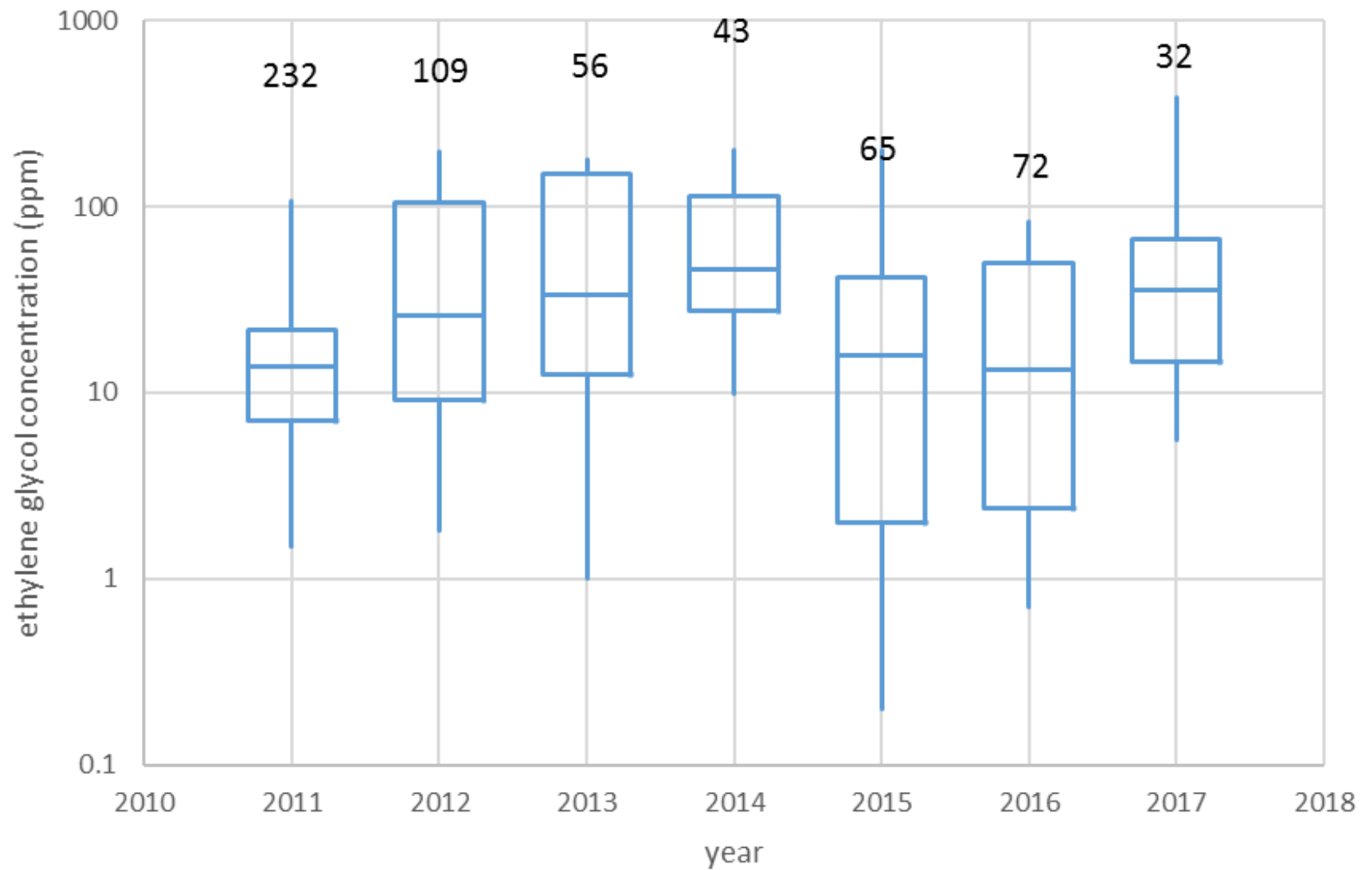
Maximum concentration of potassium hydroxide



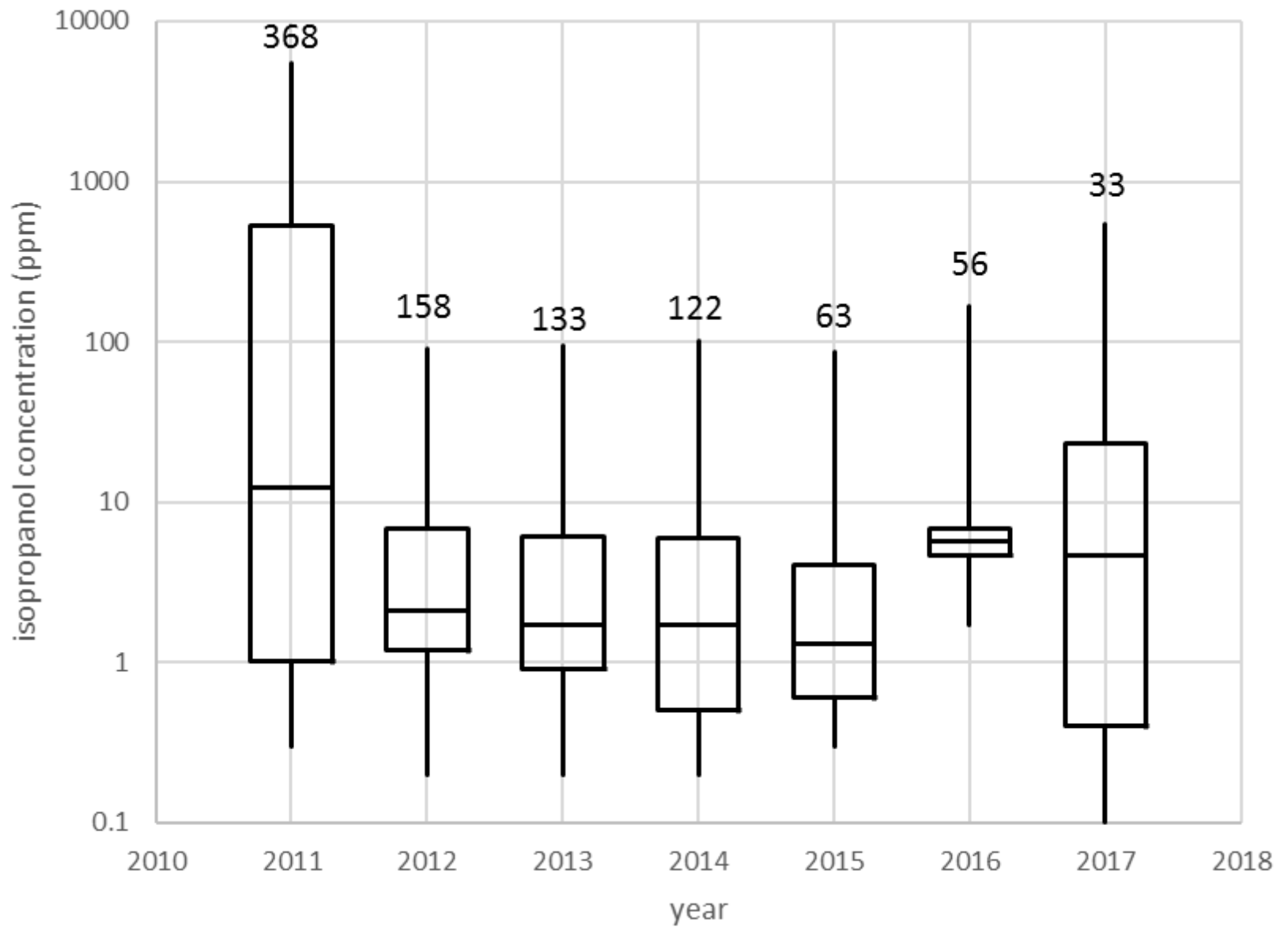
Maximum concentration of methanol/wood alcohol



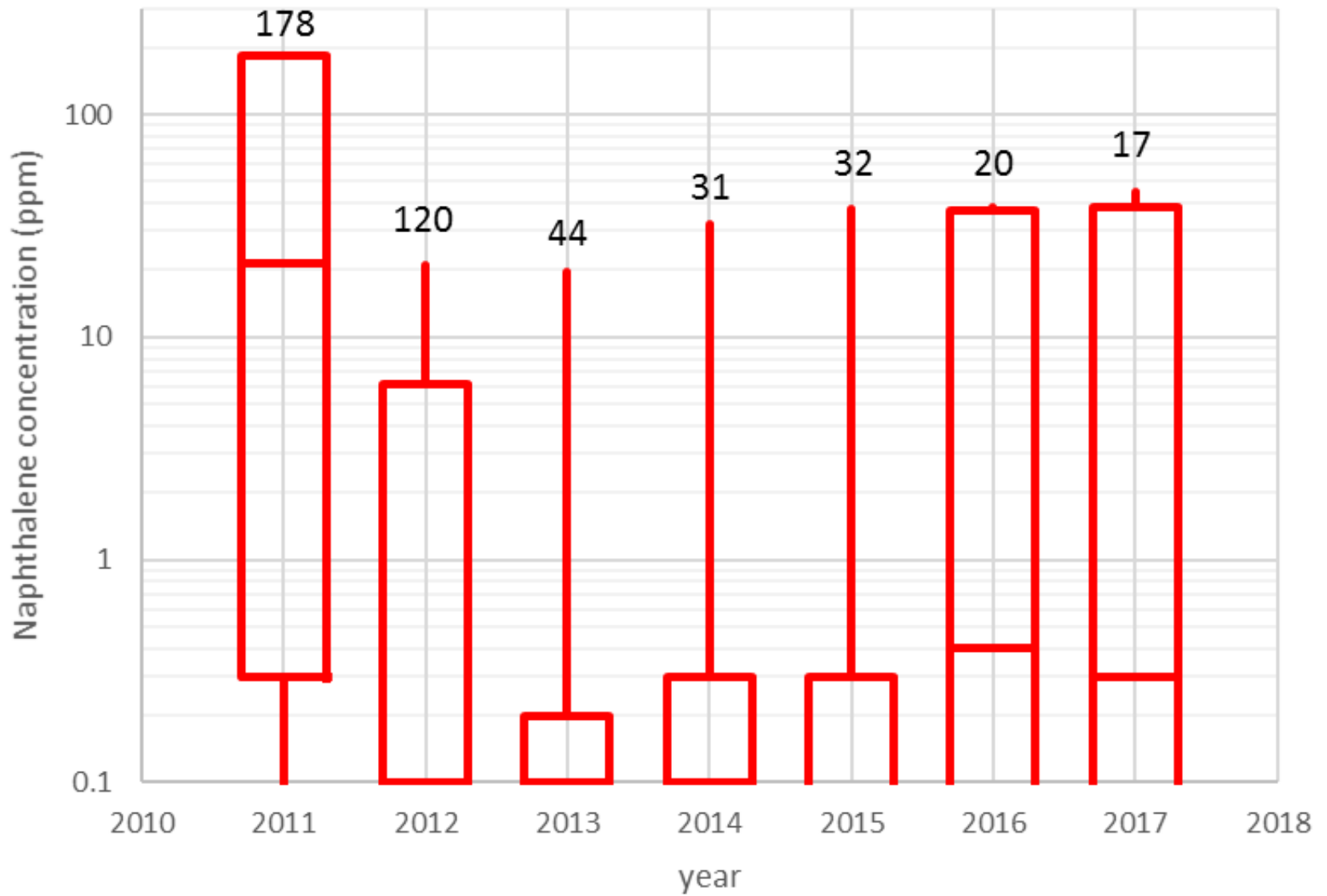
Maximum concentration of ethanol/grain alcohol



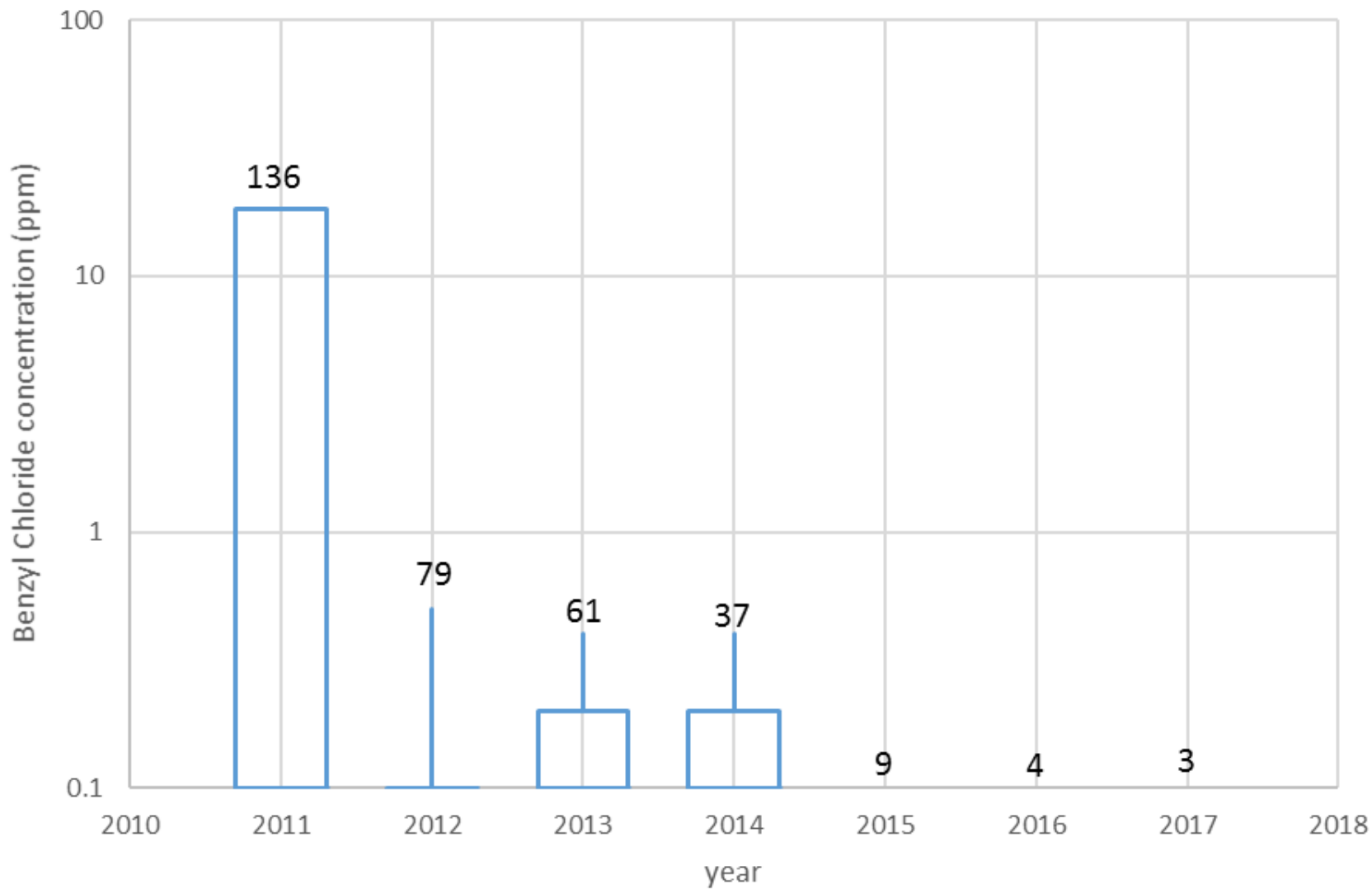
Maximum concentration of ethylene/(antifreeze/coolant)



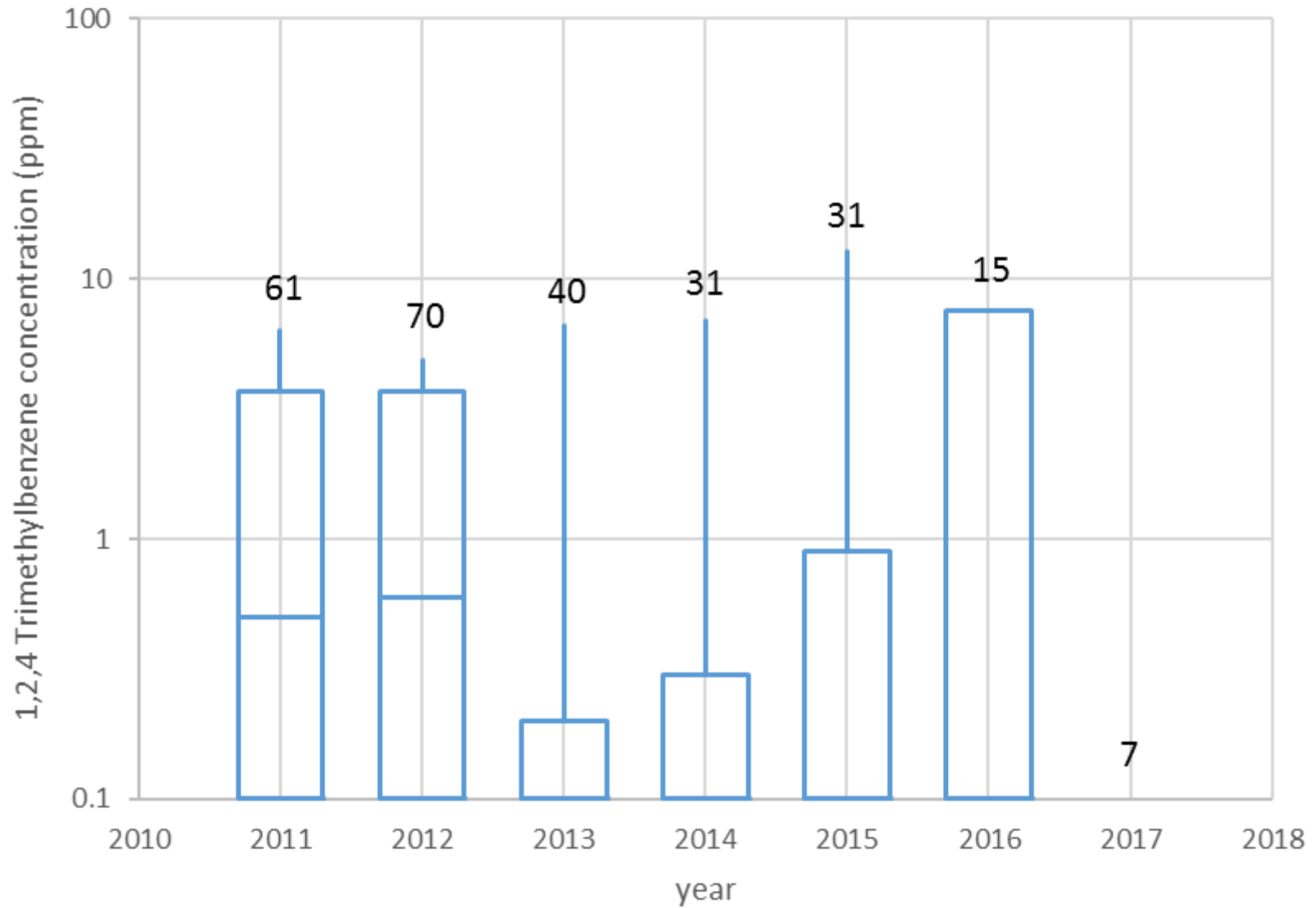
Maximum concentration of isopropanol, used as disinfectant



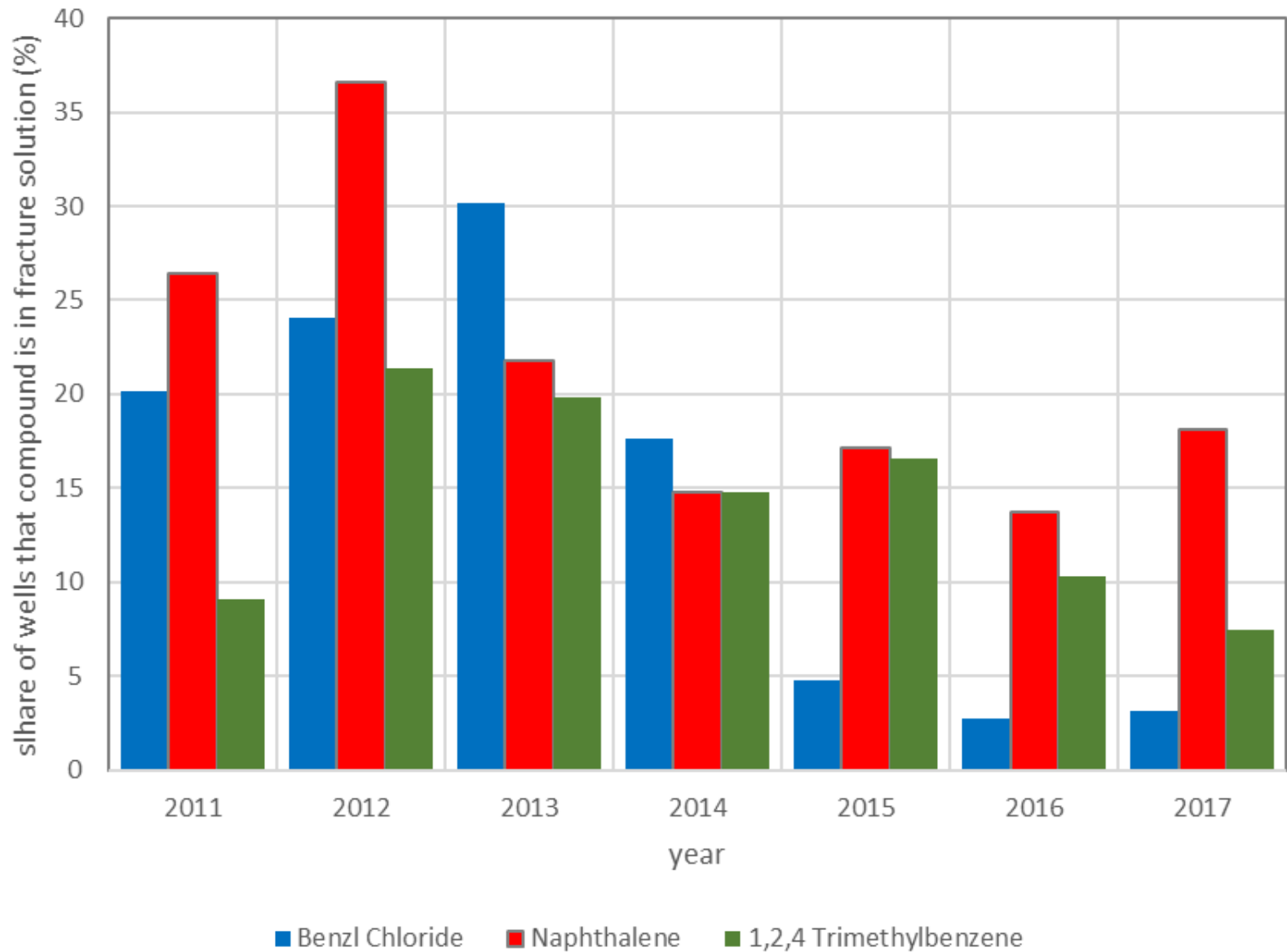
Maximum concentration of naphthalene/camphor tar/mothballs



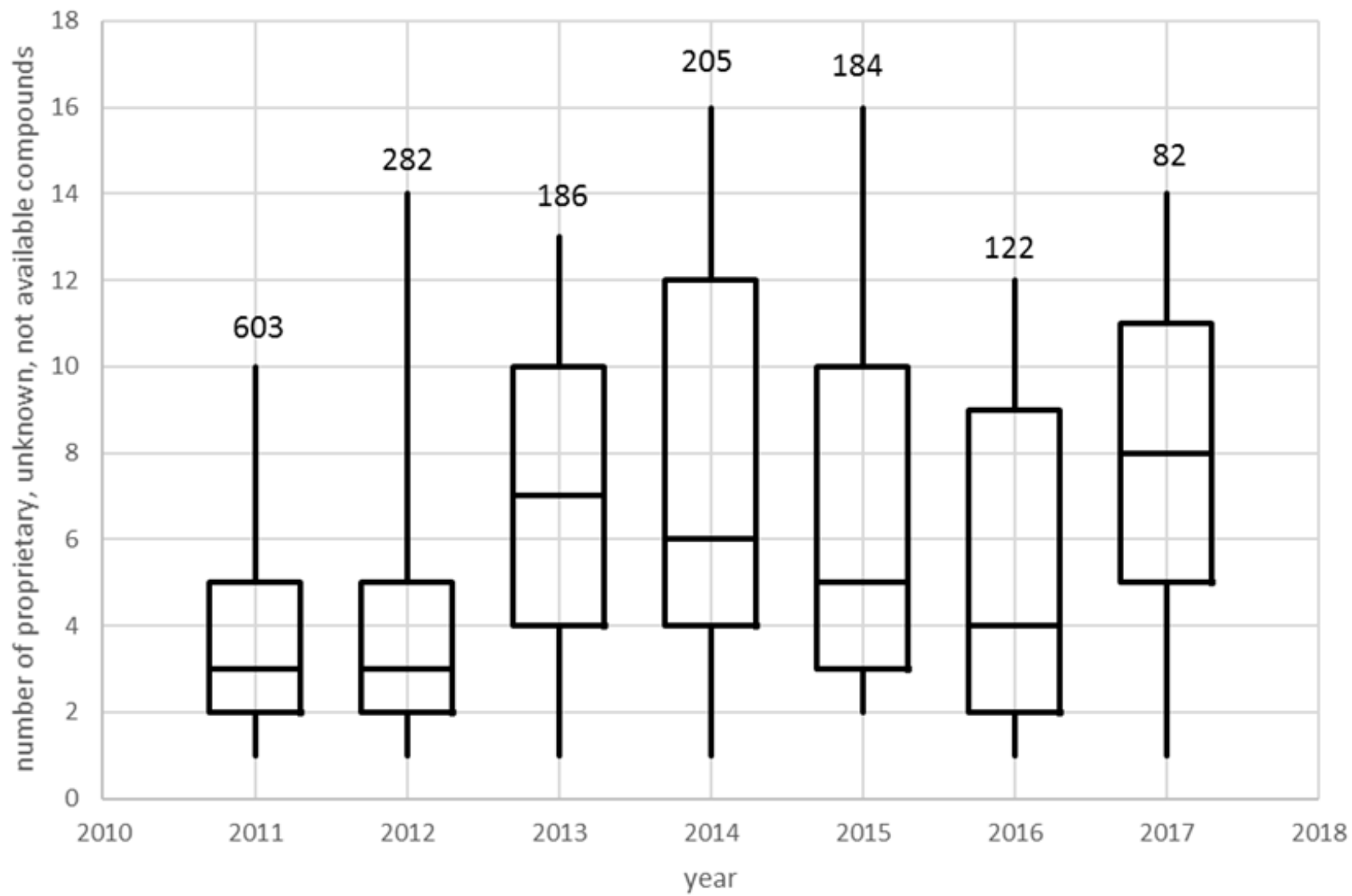
Maximum concentration of benzyl chloride/(chloromethyl)benzene



Maximum concentration of 1,2,4 trimethylbenzene used as a sterilizing agent



Share of hydraulic fracturing jobs that selected aromatics are included in the fluid mixture



Summary

- 1) Share of hydraulic fracturing jobs (HFJ) in Haysville is declining.
- 2) Volume of initial HFJ has increased by ~300% between 2011-12 to 2017-18.
- 3) Volume of re-HFJ a single well repeated is ~100% larger than initial HFJ.
- 4) Increase of median lateral length from ~4000 ft to ~8000 ft is largely driving increase in initial HFJ.
- 5) Median concentration of sand has doubled from ~6% in 2010 to ~12% in 2017.
- 6) Concentration of many compounds for example guar gum, light petroleum distillates has remained approximately constant between 2011 and 2017.
- 7) Concentration of aromatic compounds has decreased for example: naphthalene, benzyl chloride, and 1,2,4 trimethylbenzene.
- 8) Fraction of HFJ which include the aromatic: naphthalene, benzyl chloride, and 1,2,4 trimethylbenzene is decreasing between 2011 and 2017.
- 9) Increasing number of compounds used with unknown chemistry between 2011-2013 and 2015-2017.

Implications of trends for the next natural gas boom

- 1) There will be major increase of volume of water used and stress on the Wilcox Aquifer. It could about quadrupling if similar number of wells are drilled as in 2009-2011 boom.
- 2) There will be major increase of volume of sand used. It could be 700% if similar number of wells are drilled as in 2009-2011 boom.
- 3) For many other compounds they will be used in volumes 3 to 4 times volumes used as in 2009-2011 boom
- 4) Results of numbers 2 and 3 there will be a huge increase of truck traffic and related noise and road damage
- 5) Although risk of the Wilcox directly from HFJ is extremely small risks from imperfect well construction and surface accidents/spills is larger and there is a history already of accidents. These accidents will have larger impacts than for the smaller HFJ of 2009-2011 boom