

# Can we measure a reduction?

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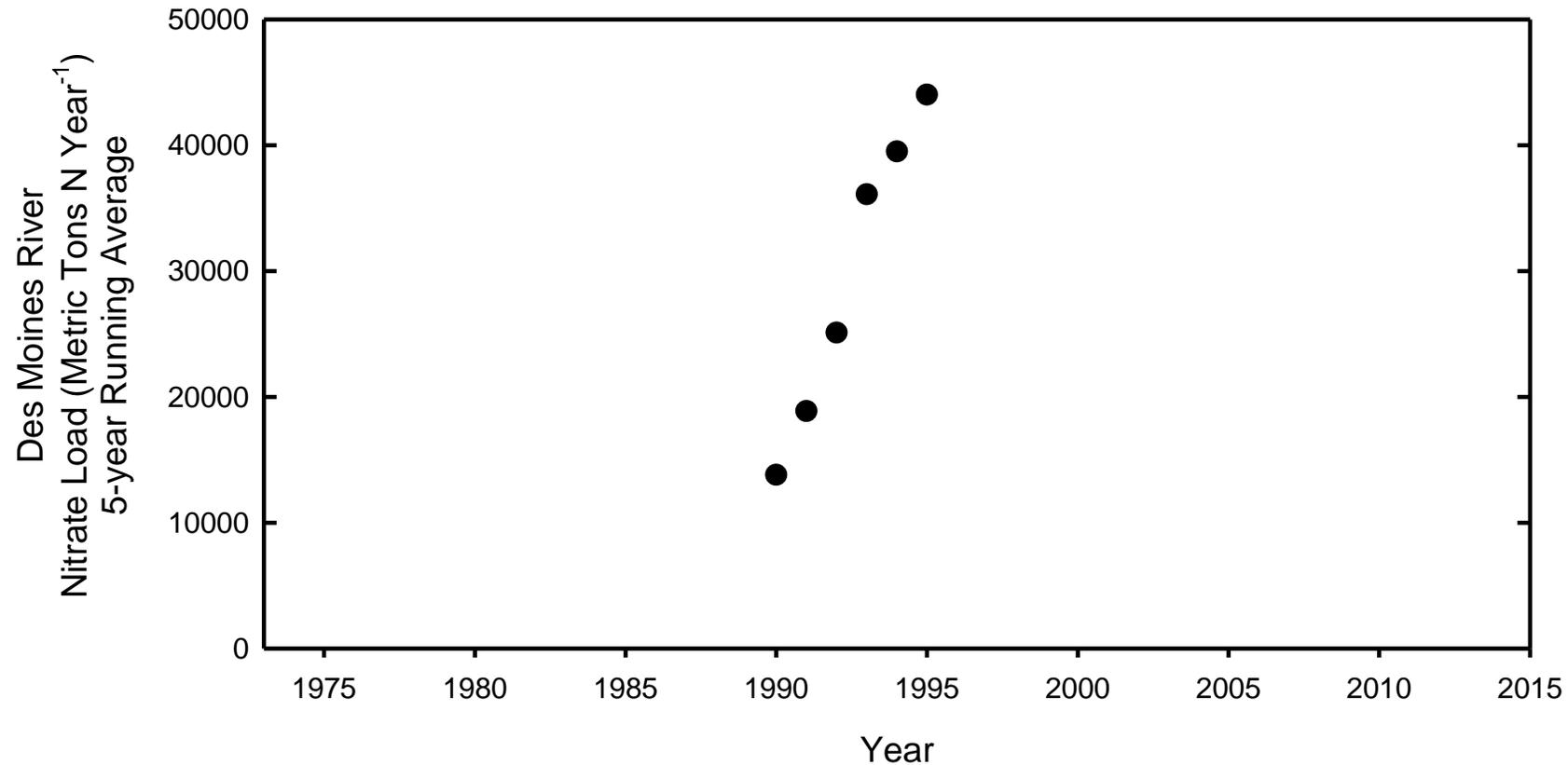
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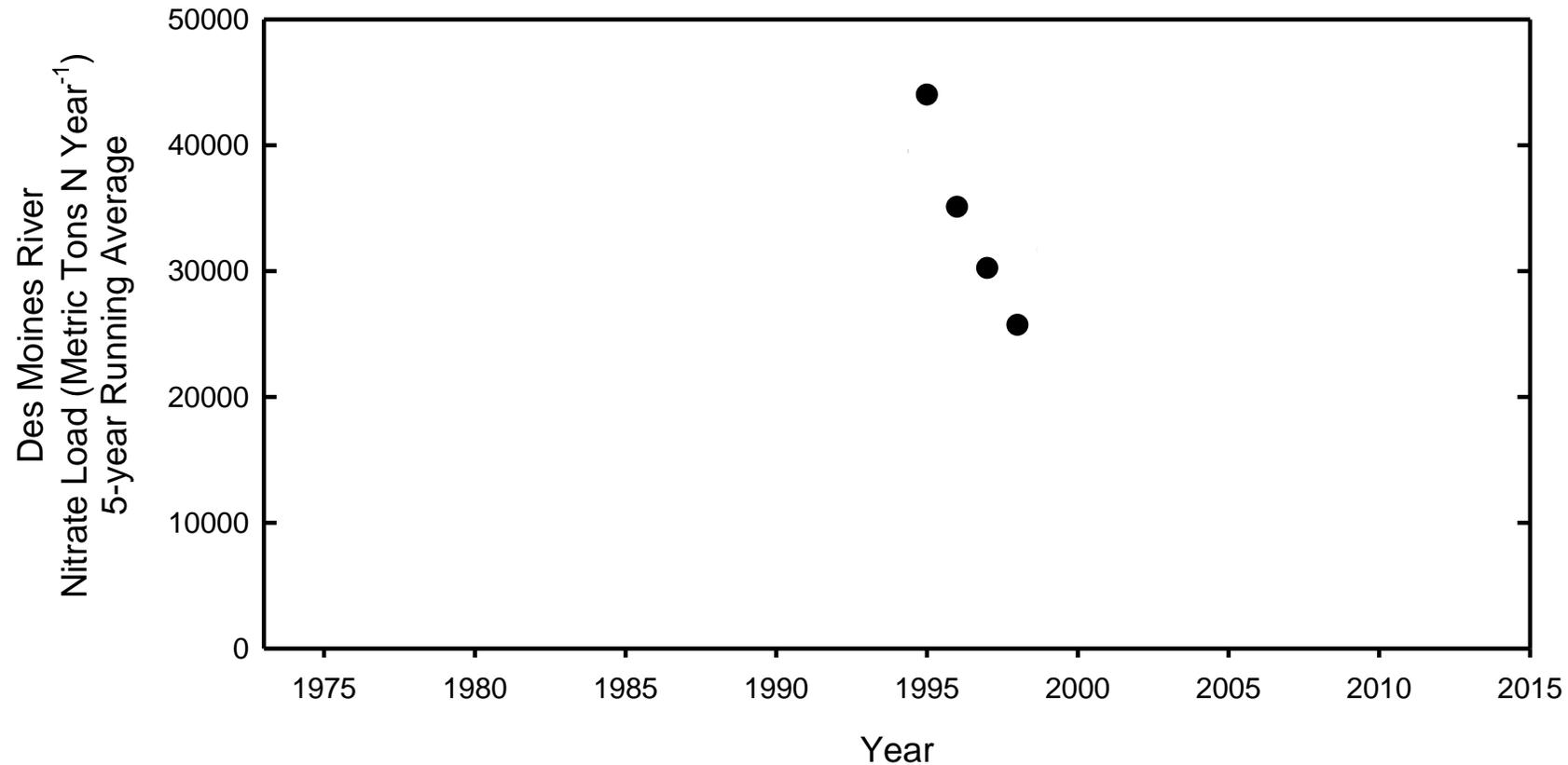
# Des Moines River Nitrate Load @ DMWW

- 5 year running averages



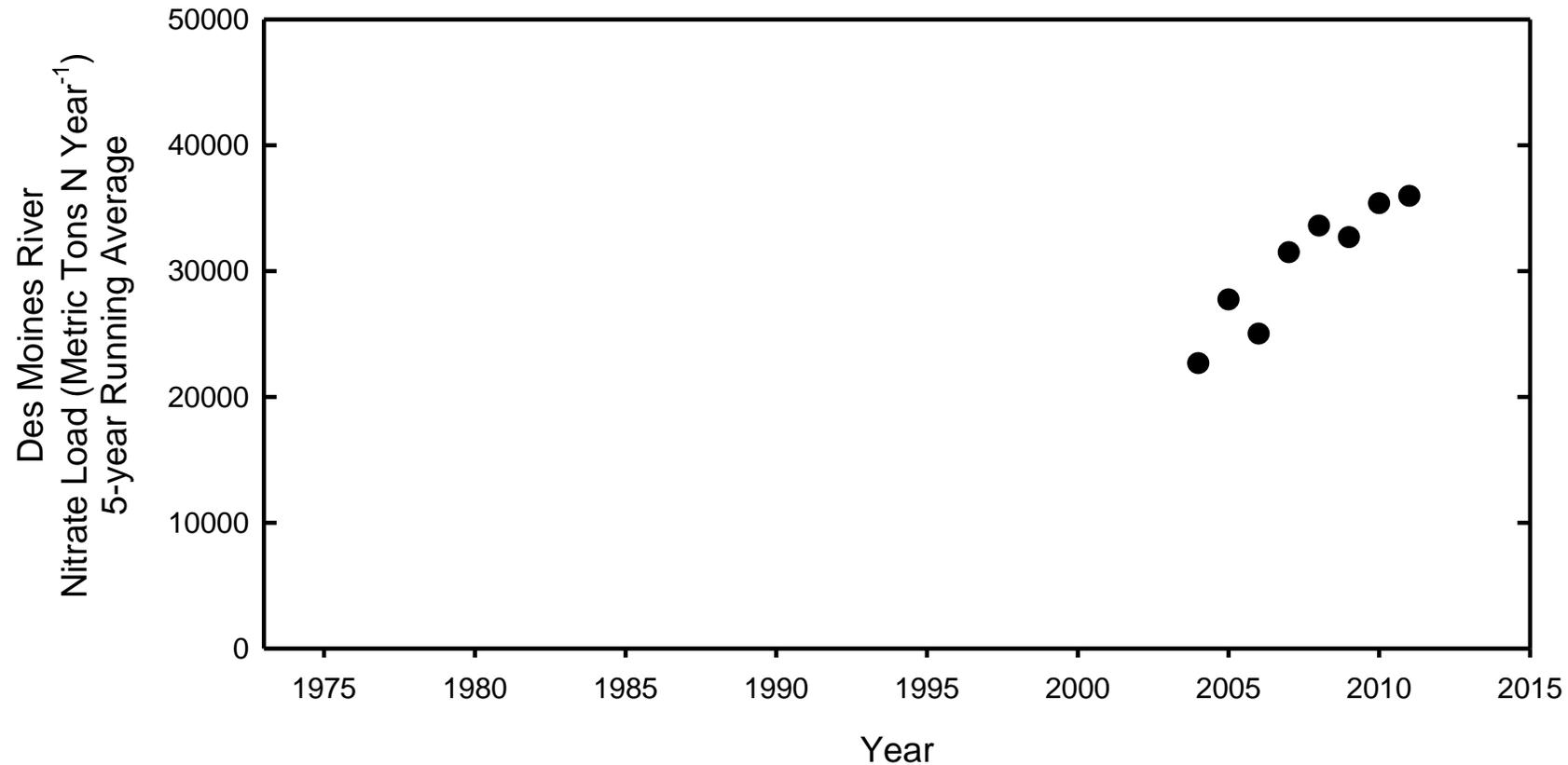
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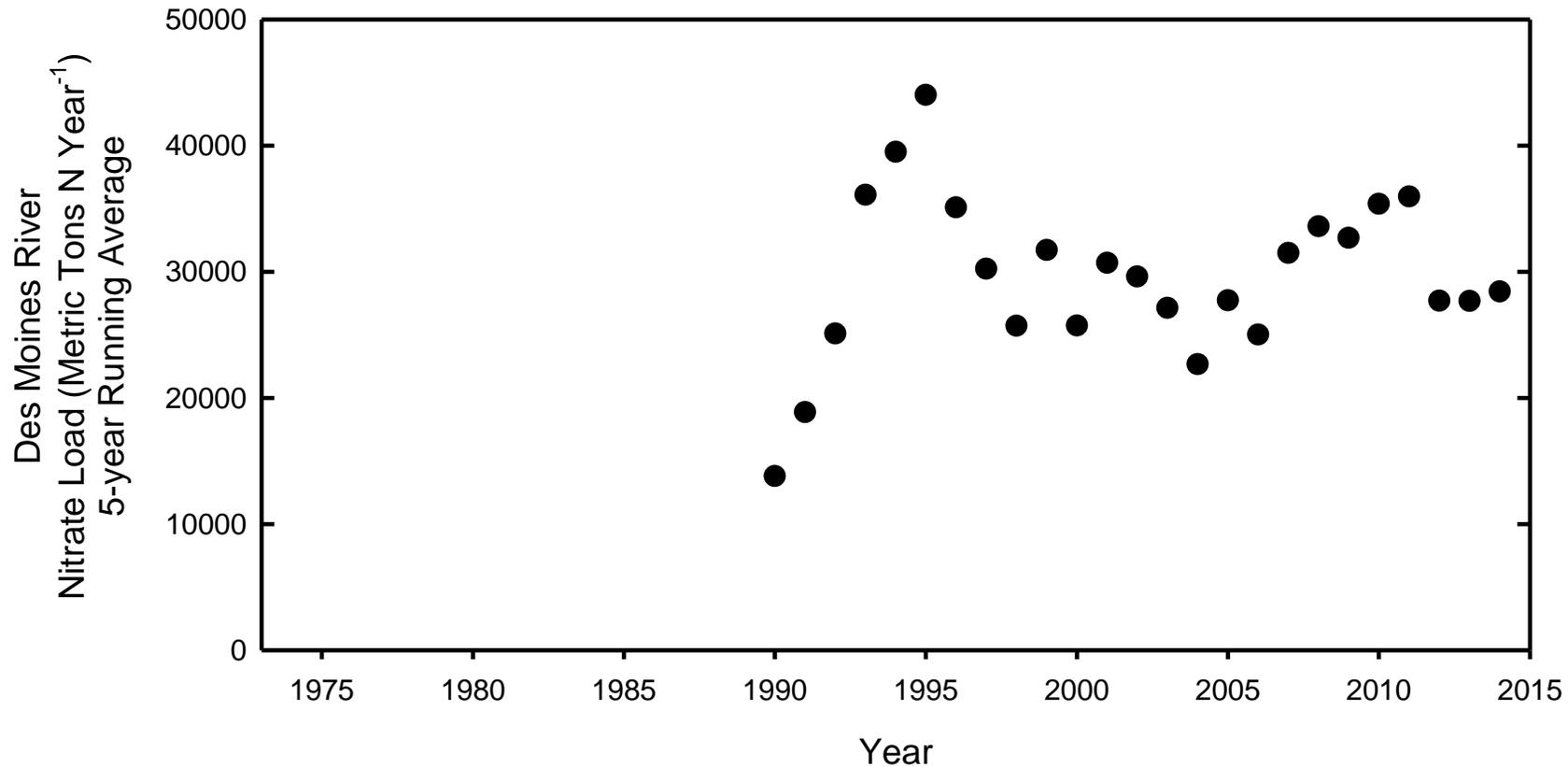
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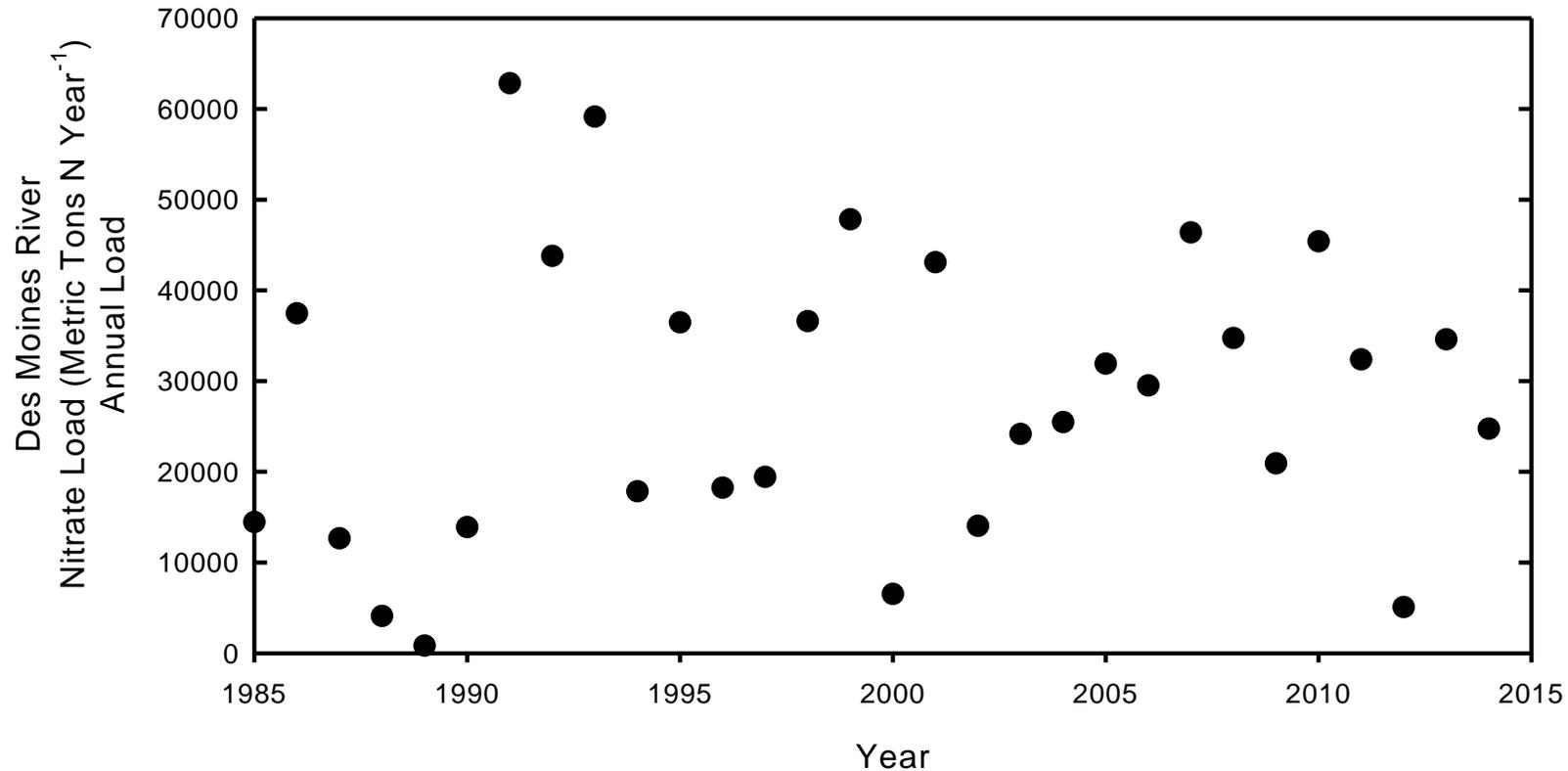
# Des Moines River Nitrate Load @ DMWW

- 5 year running average did not change from 1986-2014:  
29661 Mt/year with a SD of 6423 Mt/year. ***5-year running average displayed below.***



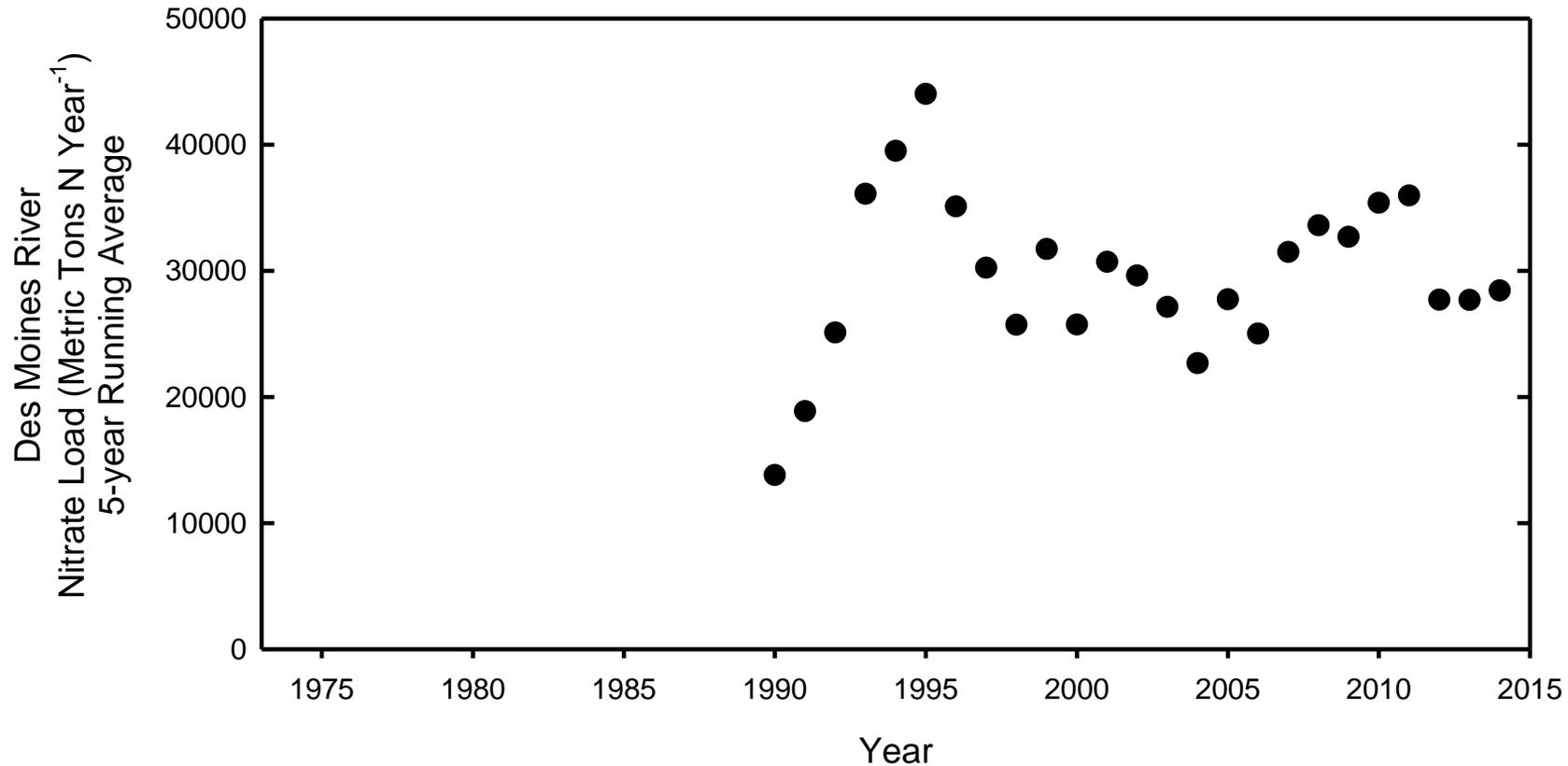
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- 5 year running average did not change from 1986-2014:  
29661 Mt/year with a SD of 6423 Mt/year. ***Raw data displayed below.***



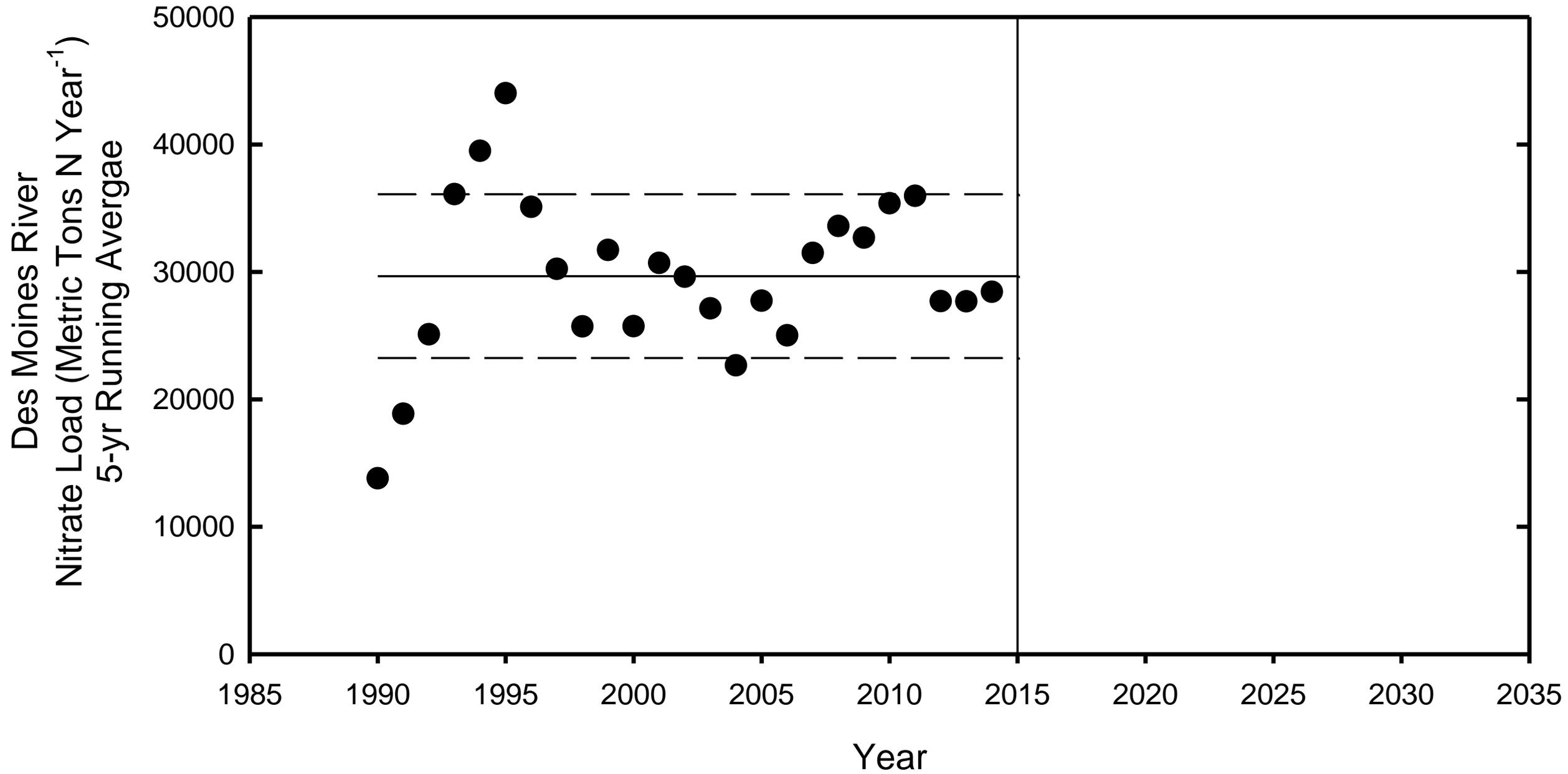
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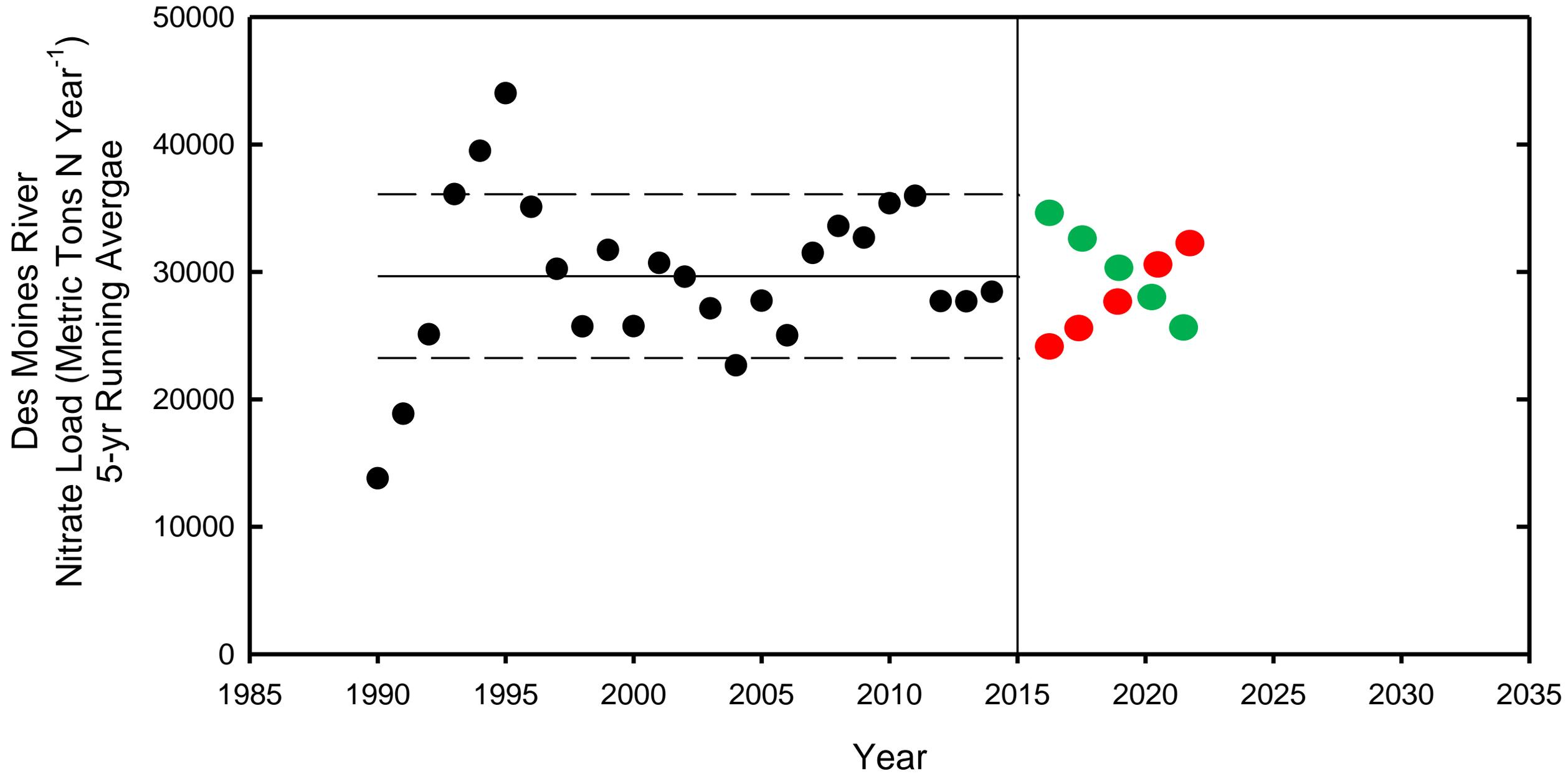
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# How Monte Carlo Simulations Work:

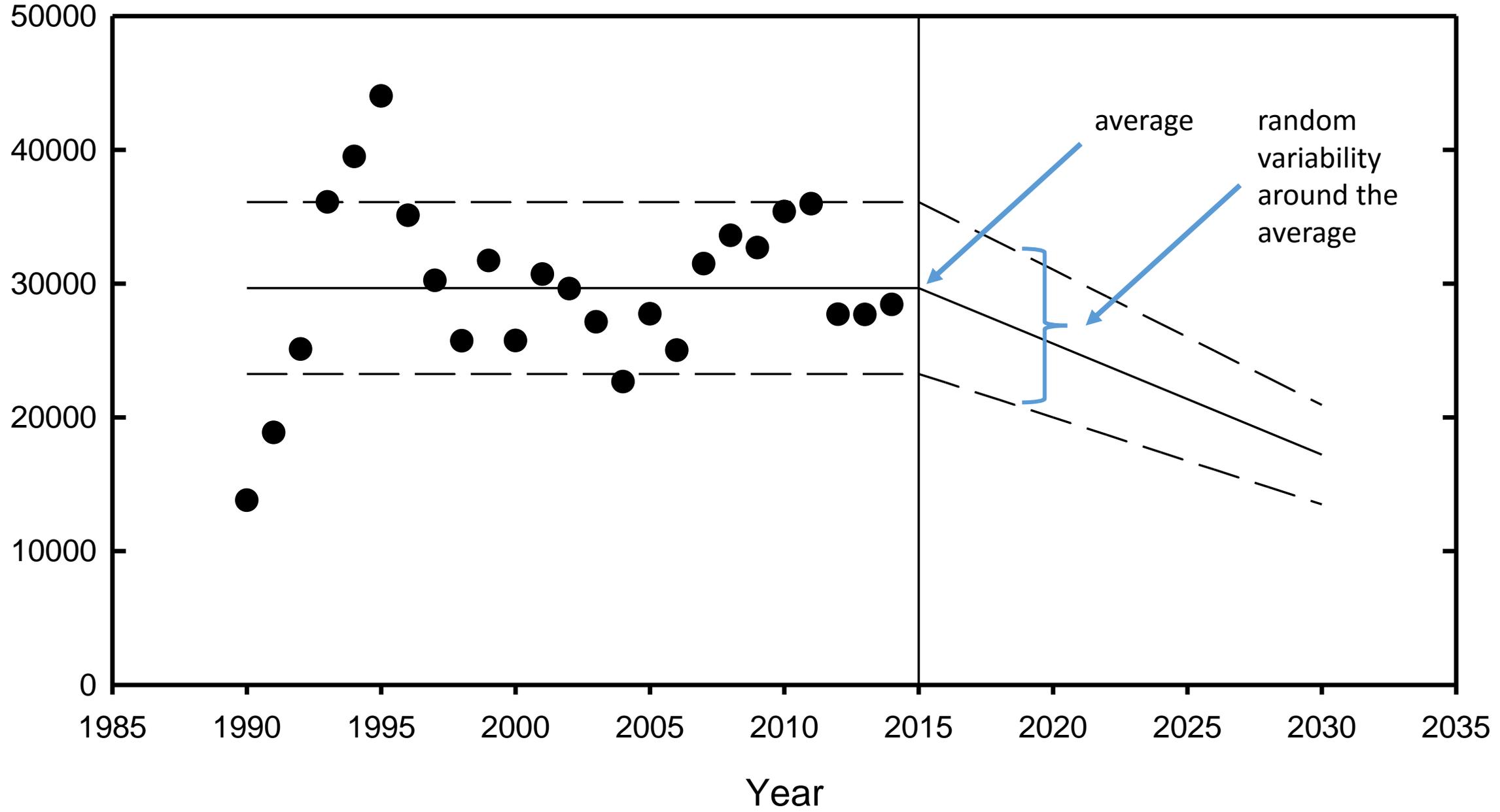
- Based on the natural variability in the data, it's possible to measure outcomes that do not exist (false).
- **An example:** The average weight of a baby is 7.5 lbs, but the natural range is 5.5 to 10 lbs.
  - There are 5 babies born over the next 5 days with the following weights:  
Day 1: 7.5lbs.; Day 2: 8.0lbs.; Day 3: 8.5lbs.; Day 4: 9.0lbs.; Day 5: 9.5lbs.
- *Would you conclude that the average weight of babies is increasing?*
  - *No, it was the 'luck of the draw' and thus the Monte Carlo approach.*
- Monte Carlo simulation asks the probability of such an occurrence

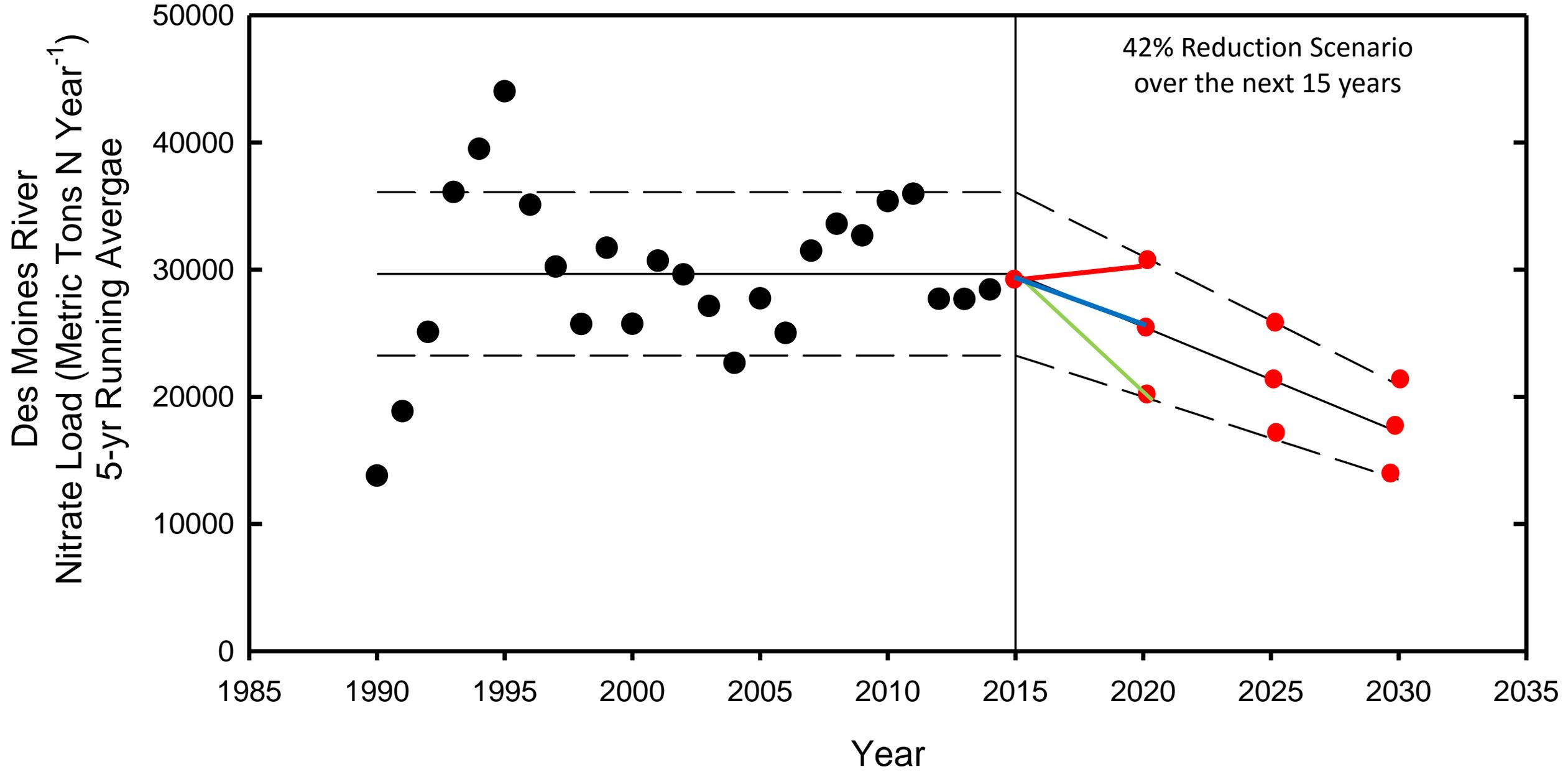


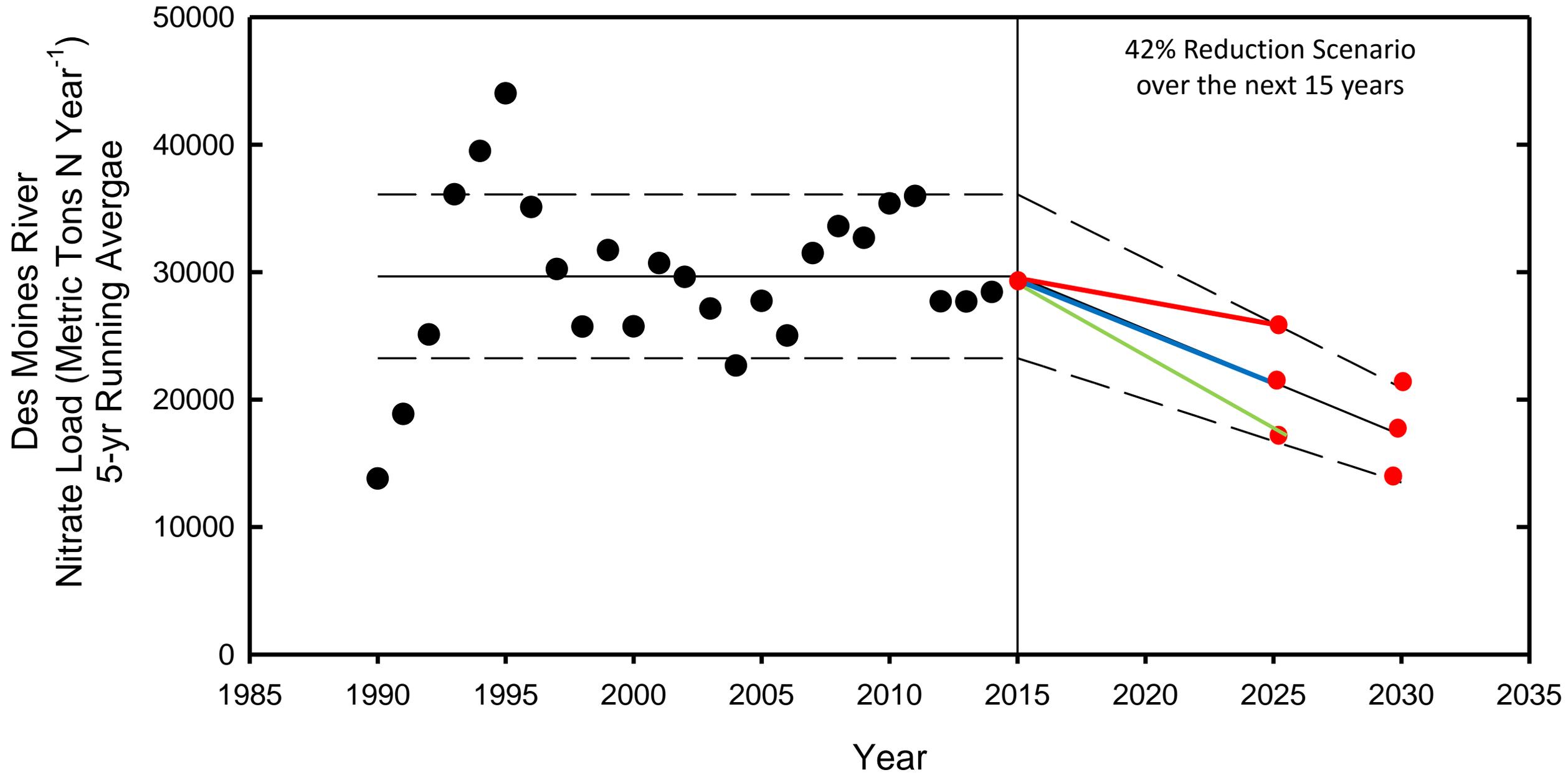


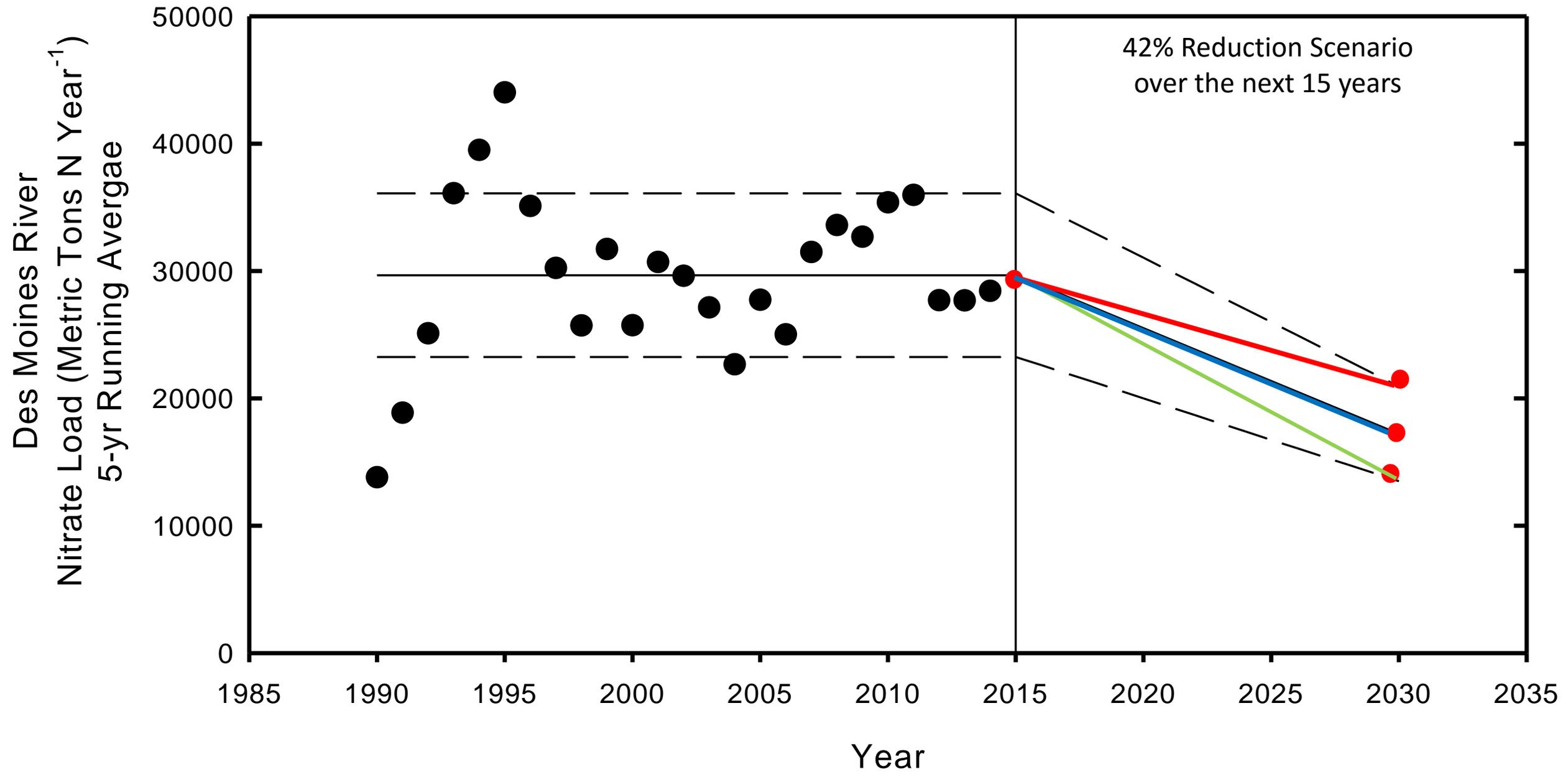
# Des Moines River

Nitrate Load (Metric Tons N Year<sup>-1</sup>)  
5-yr Running Average

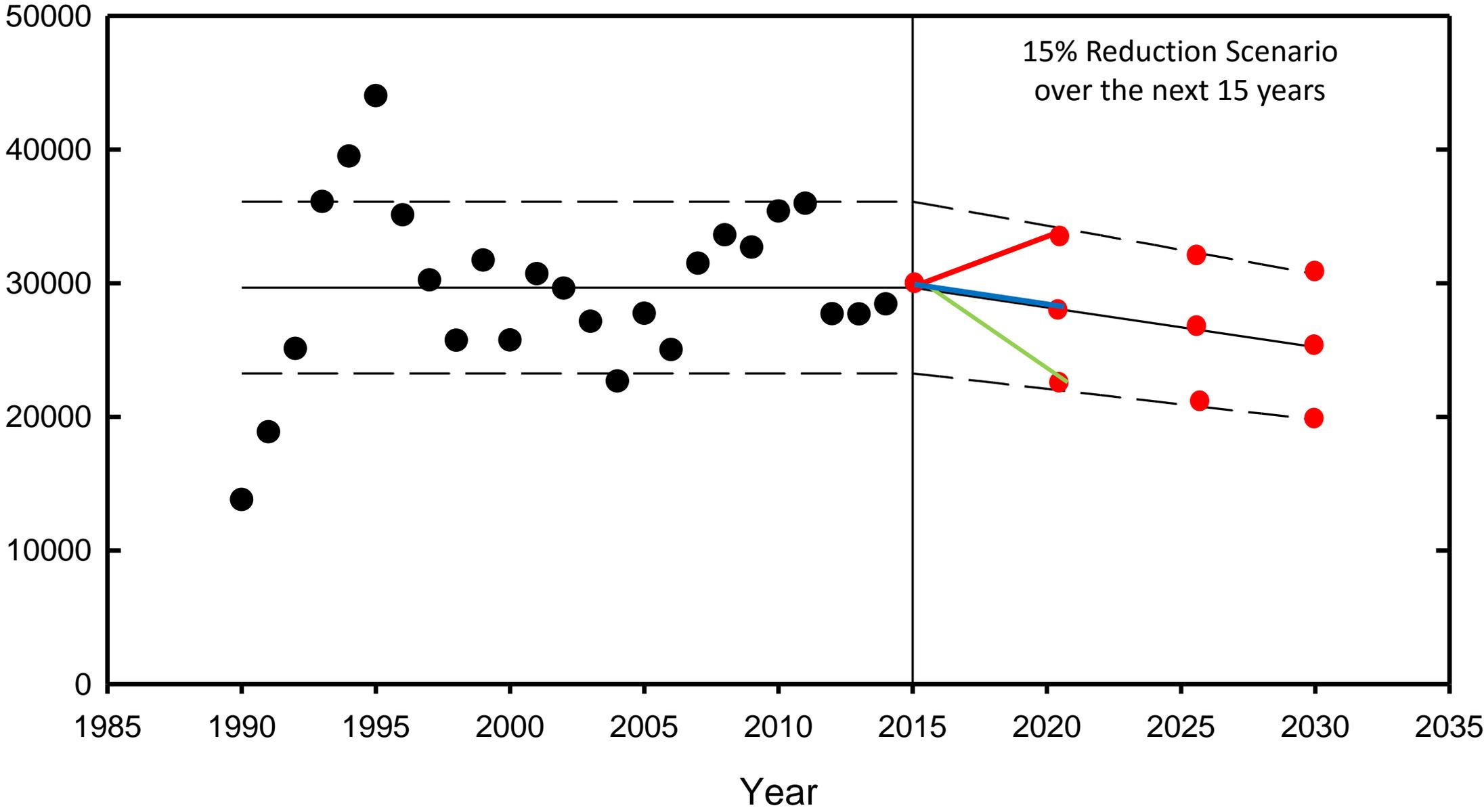




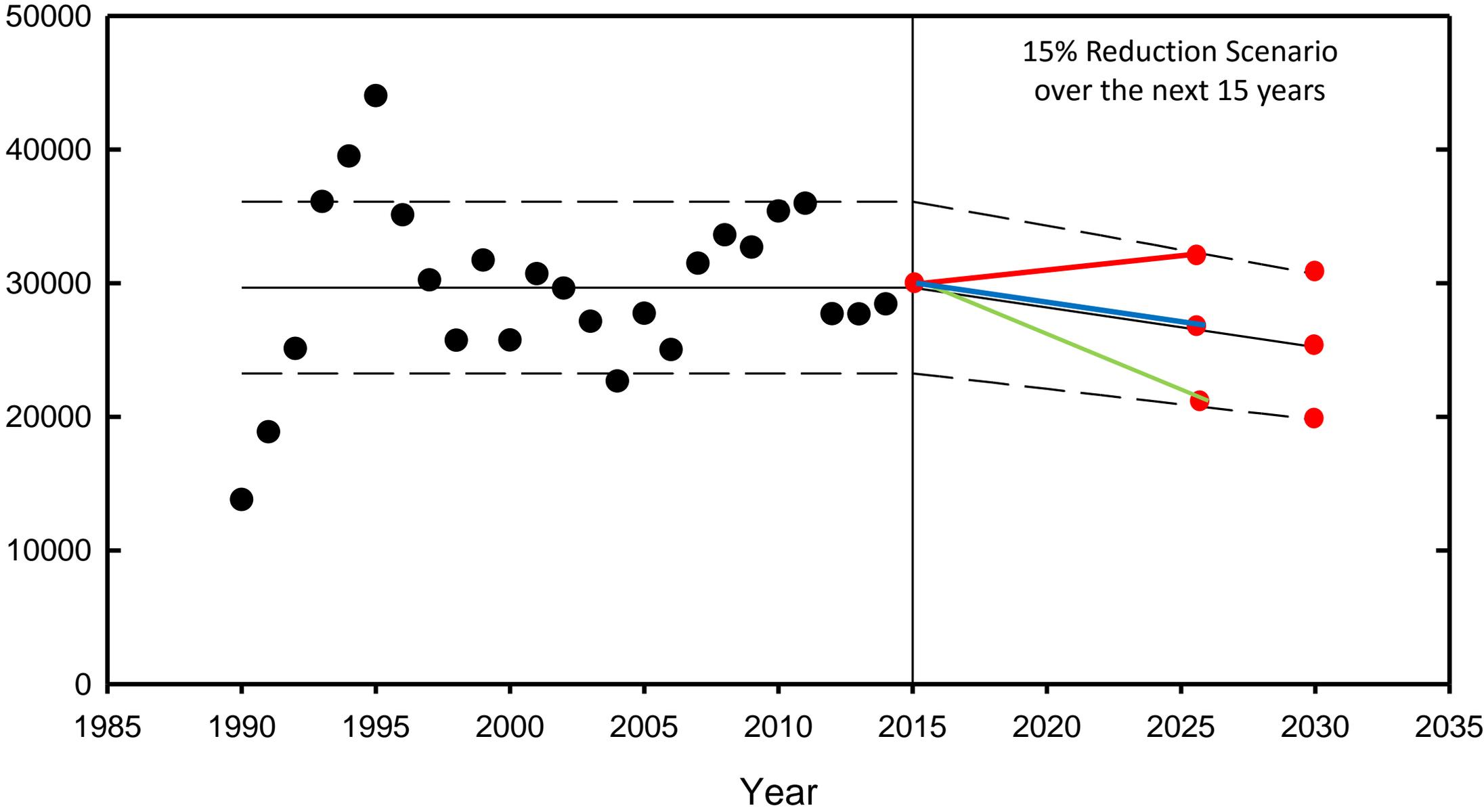




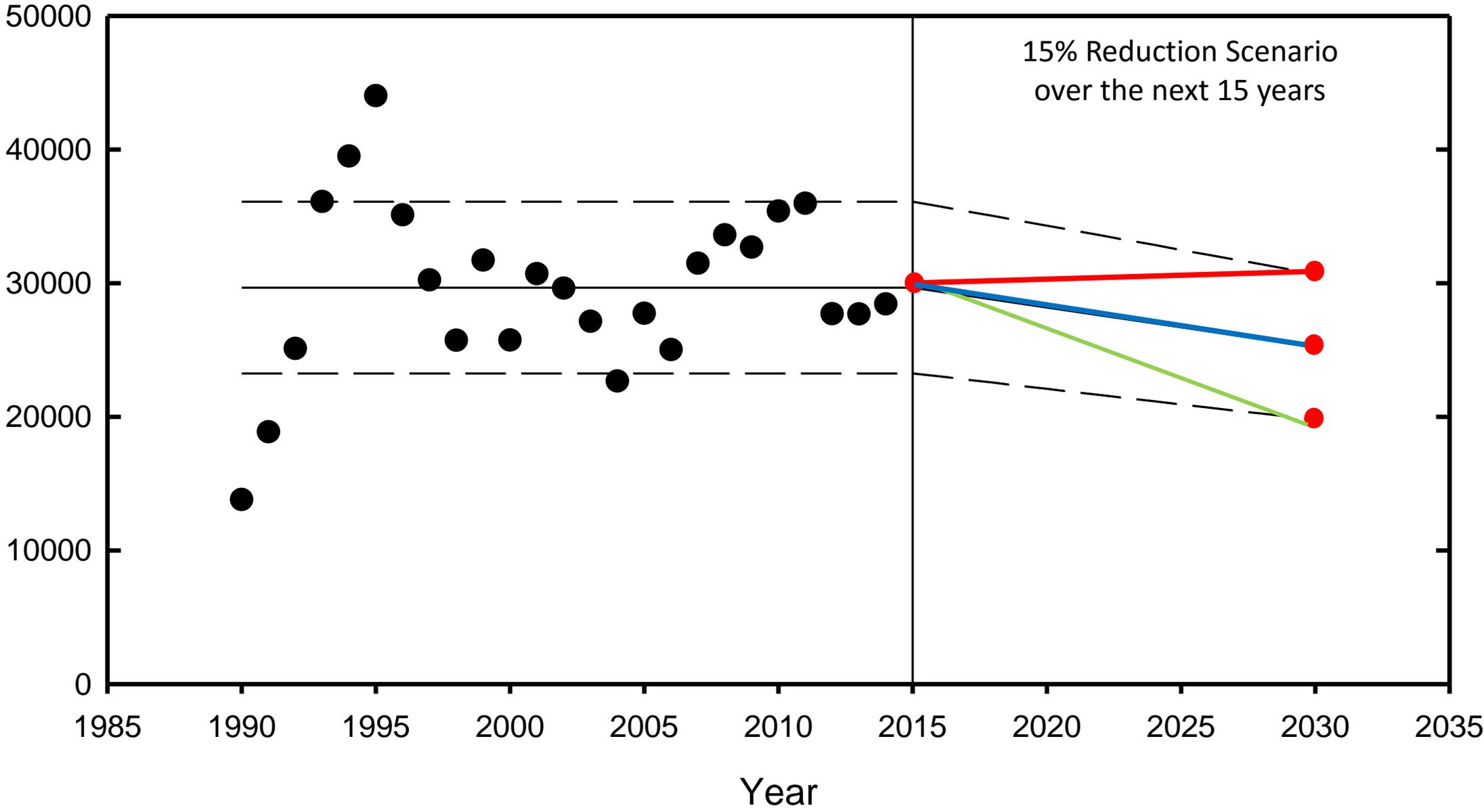
Des Moines River  
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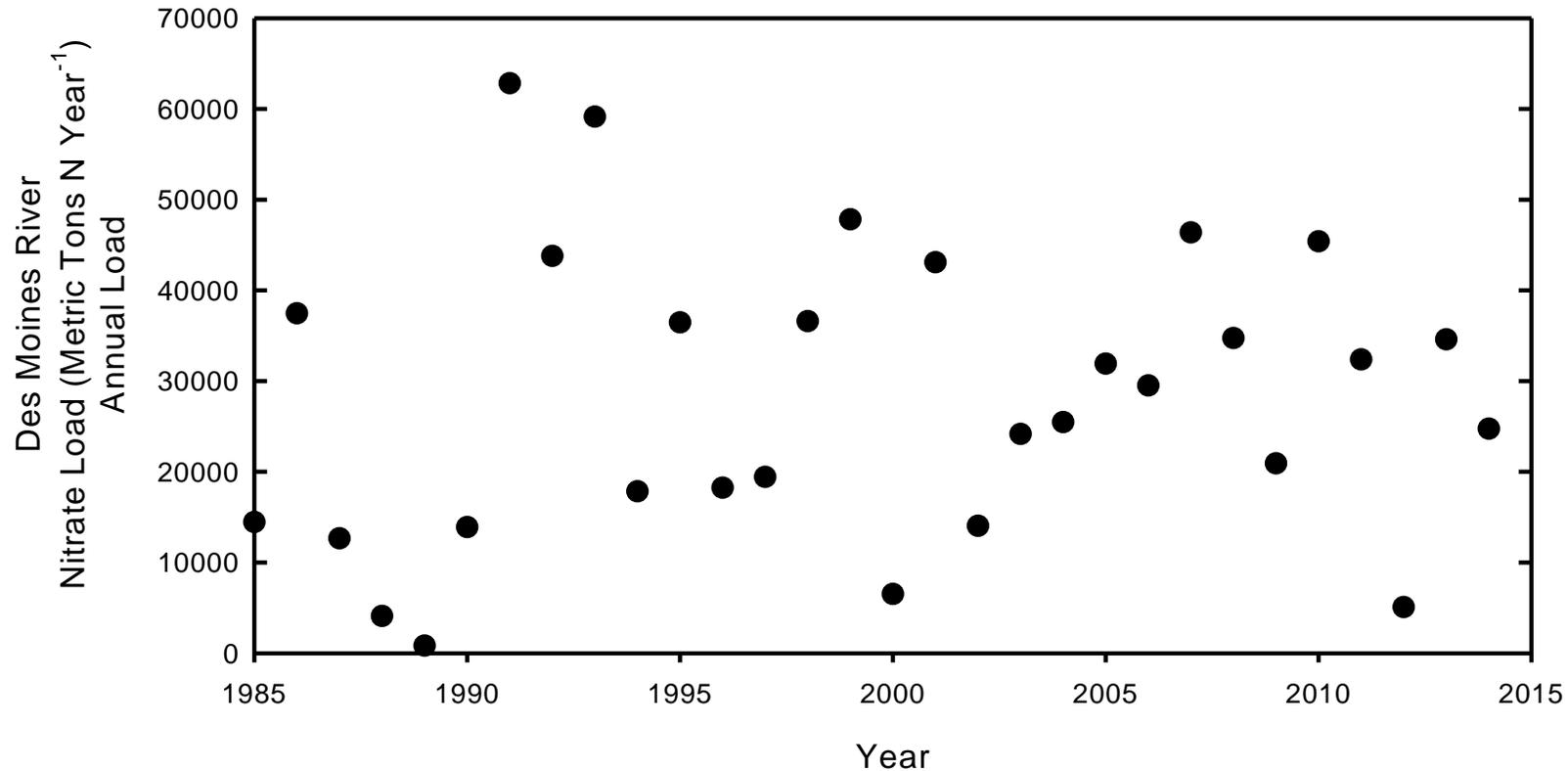


Des Moines River  
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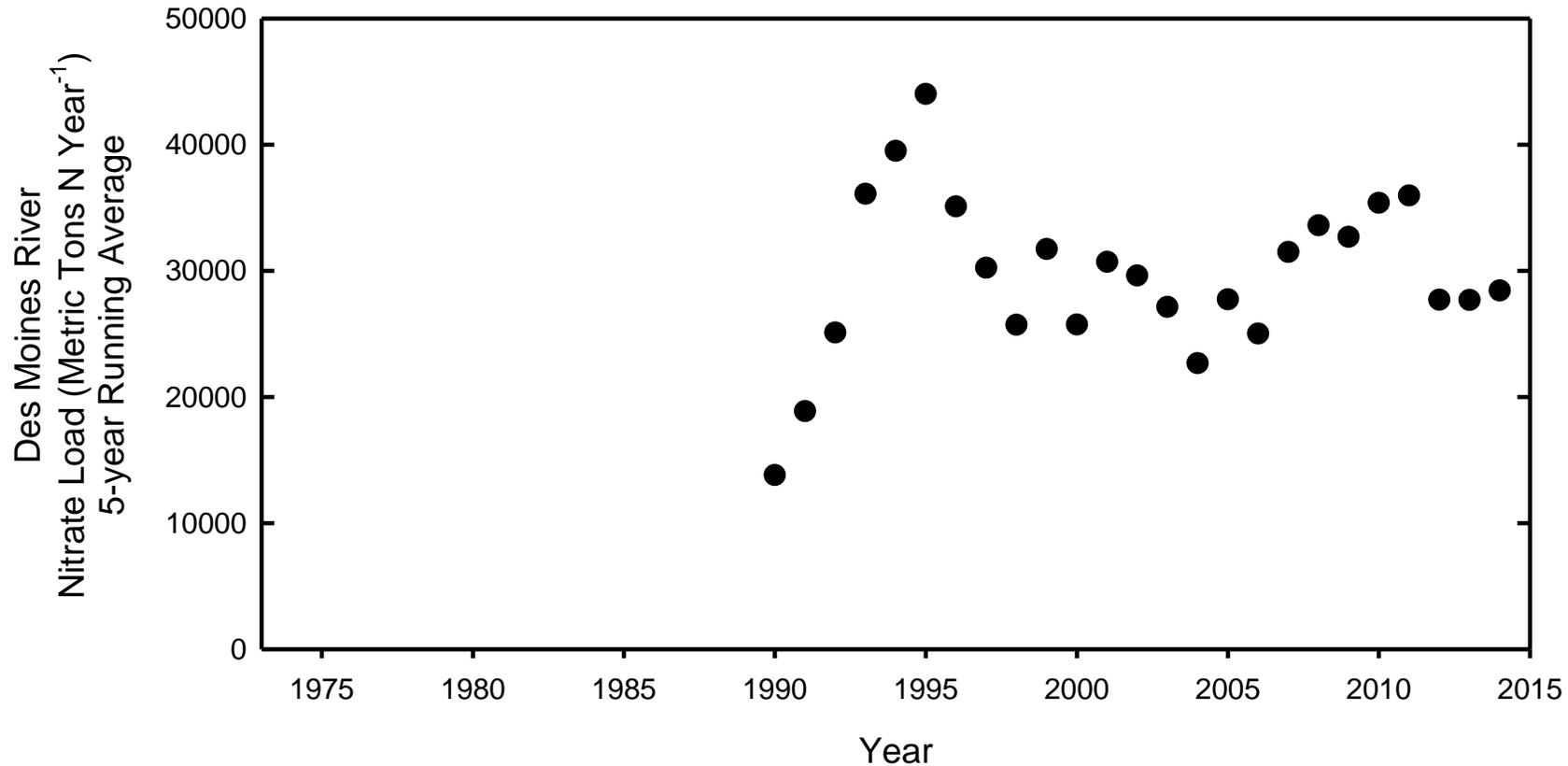
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- 5 year running average did not change from 1986-2014:  
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Average annual load reduction required to achieve a  
 5, 10, 20 or 43% reduction over 5, 10 or 20 years.  
 (Mt/year)

|                 | Percent Load Reduction Over the Timeline                               |     |      |      |
|-----------------|--|-----|------|------|
|                 | 5%   | 10% | 20%  | 42%  |
| Timeline        | Annual load reduction required to achieve above reductions<br>(Mt N/y) |     |      |      |
| <b>5 Years</b>  | 371  | 742 | 1483 | 3115 |
| <b>10 Years</b> | 165  | 330 | 659  | 1384 |
| <b>20 Years</b> | 78   | 156 | 312  | 655  |

## Proportion of simulations that measure a significant load reduction.

In other words, *power* or the percent chance of measuring a significant reduction if there was actual reduction of 5, 10, 20 or 42%.

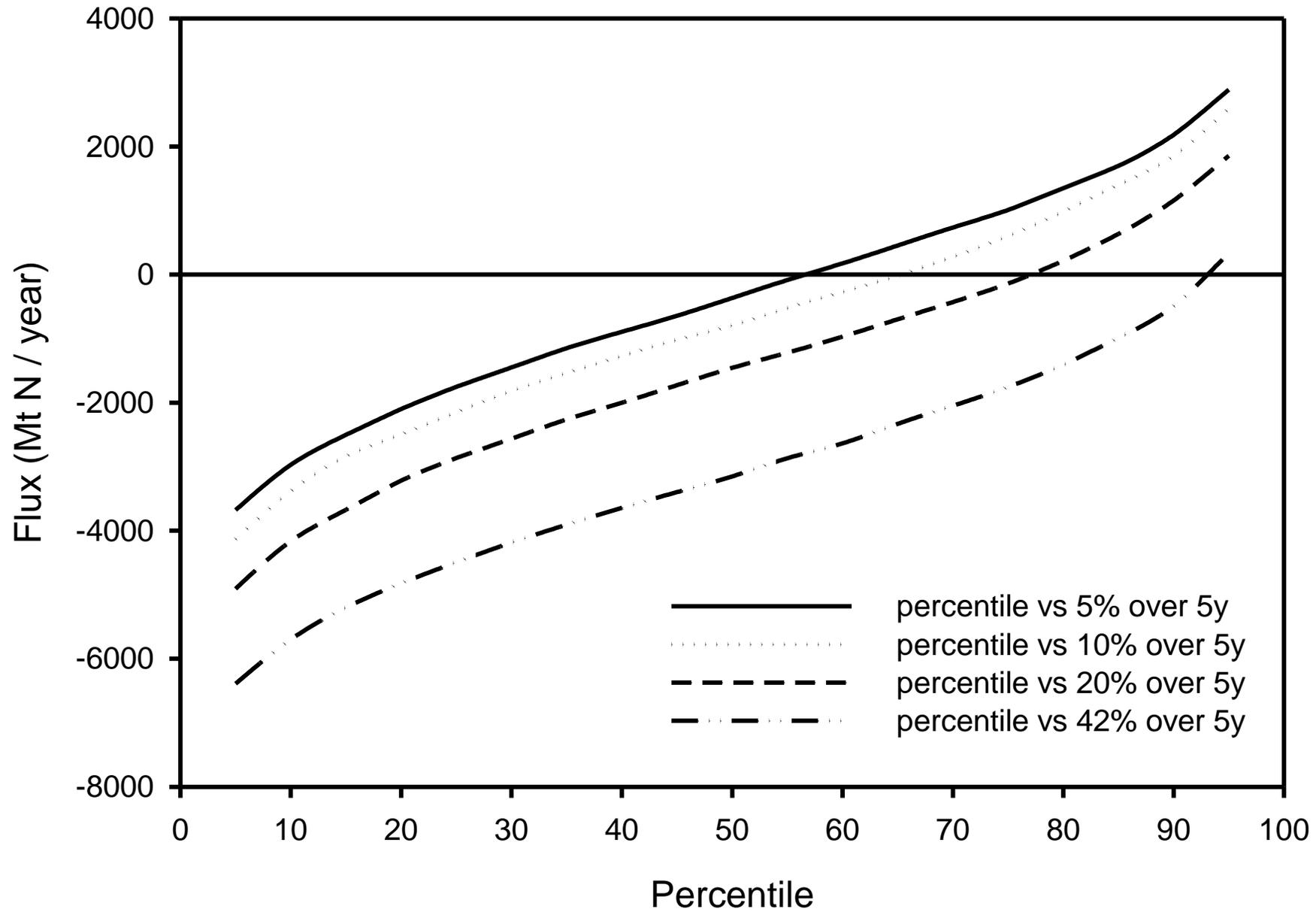
|          | Percent Load Reduction Over the Timeline   |      |      |     |
|----------|--|------|------|-----|
|          | 5%   | 10%  | 20%  | 42% |
| Timeline | Proportion of Simulations resulting in a significant ( $p < 0.05$ ) load reduction |      |      |     |
| 5 Years  | 3.5%   | 4.5% | 8.0% | 18% |
| 10 Years | 4.0%   | 6.0% | 13%  | 40% |
| 20 Years | 4.5%   | 8.5% | 22%  | 70% |

## Proportion of simulations that measure a decline in load (negative slope over time).

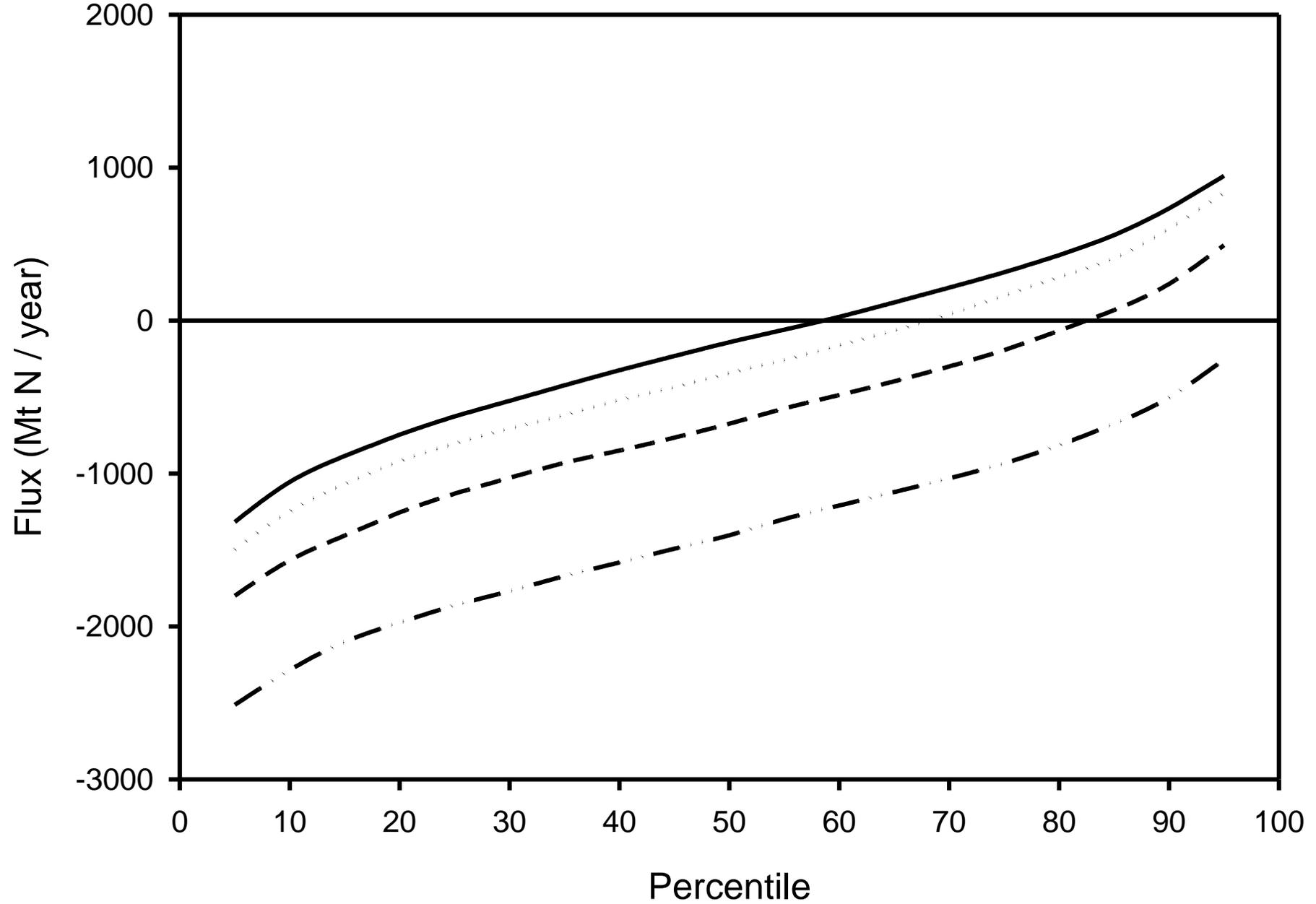
Slope may be significantly or non-significantly negative. In other words, how many simulations produced data with a negative slope? These results, subtracted from the 100% of model runs reveal the proportion of time when an increase would be measured despite the actual reduction in load.

|          | Percent Load Reduction Over the Timeline   |     |     |      |
|----------|--|-----|-----|------|
|          | 5%   | 10% | 20% | 42%  |
| Timeline | Proportion of simulations that measure a decline in load regardless of whether or not decline is significant |     |     |      |
| 5 Years  | 55%  | 60% | 75% | 90%  |
| 10 Years | 55%  | 65% | 80% | 100% |
| 20 Years | 60%  | 70% | 85% | 100% |

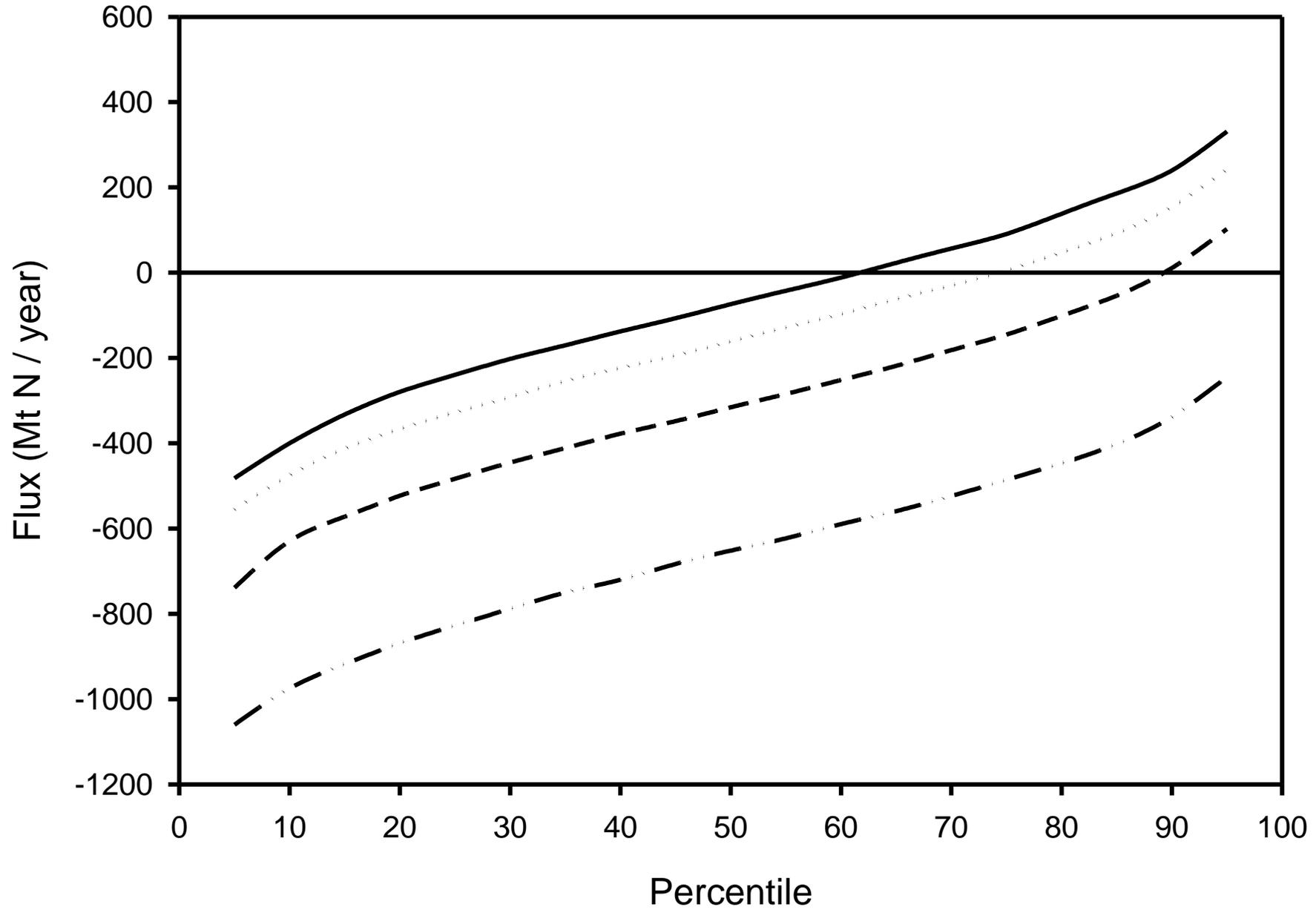
Percentile distribution of 5, 10, 15, 20, 42% reductions over 5 years



Percentile distribution of 5, 10, 15, 20, 42% reductions over 10 years

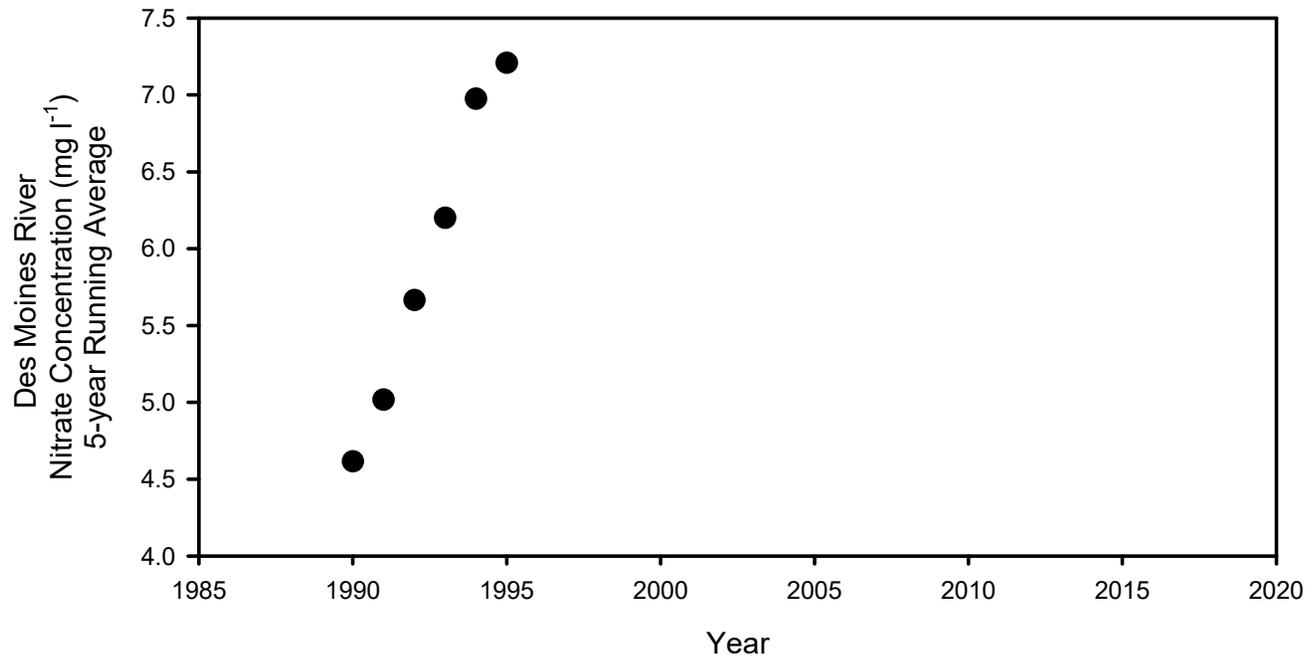


Percentile distribution of 5, 10, 15, 20, 42% reductions over 20 years



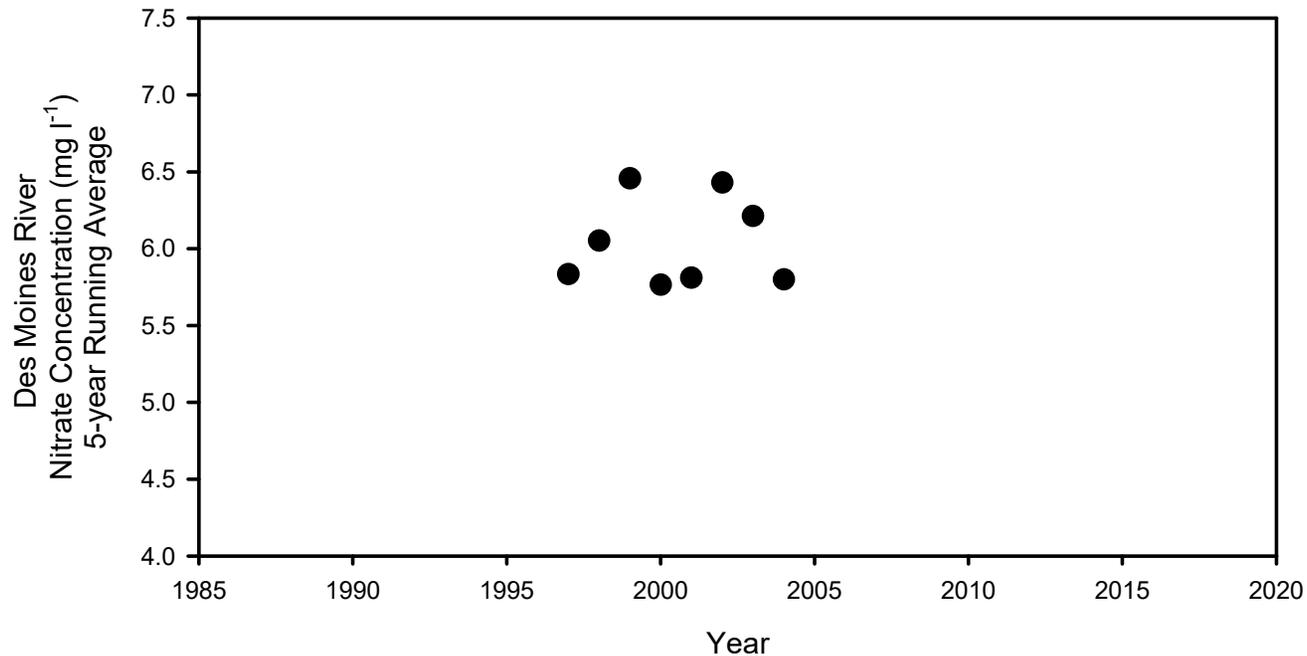
# Des Moines River Nitrate Conc. @ DMWW

- 5 year running average of annual average concentration did not change from 1986-2014: 6.0 mg/L SD=0.8 ***5-yr running average displayed below***



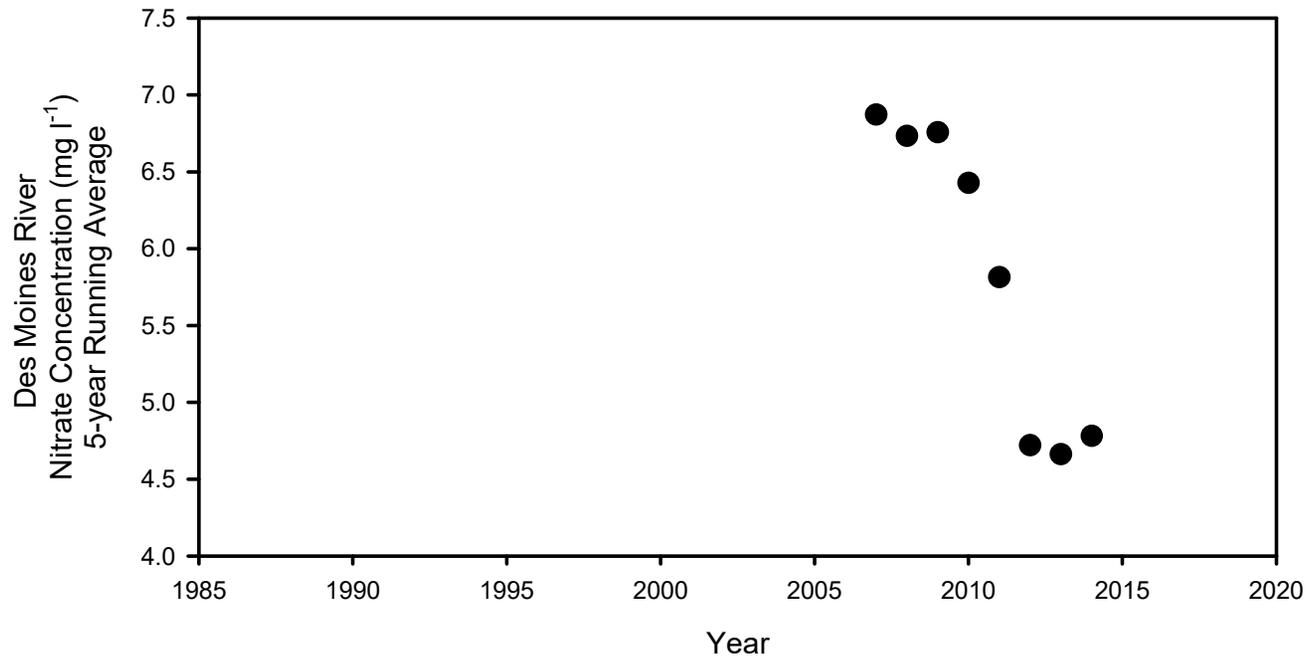
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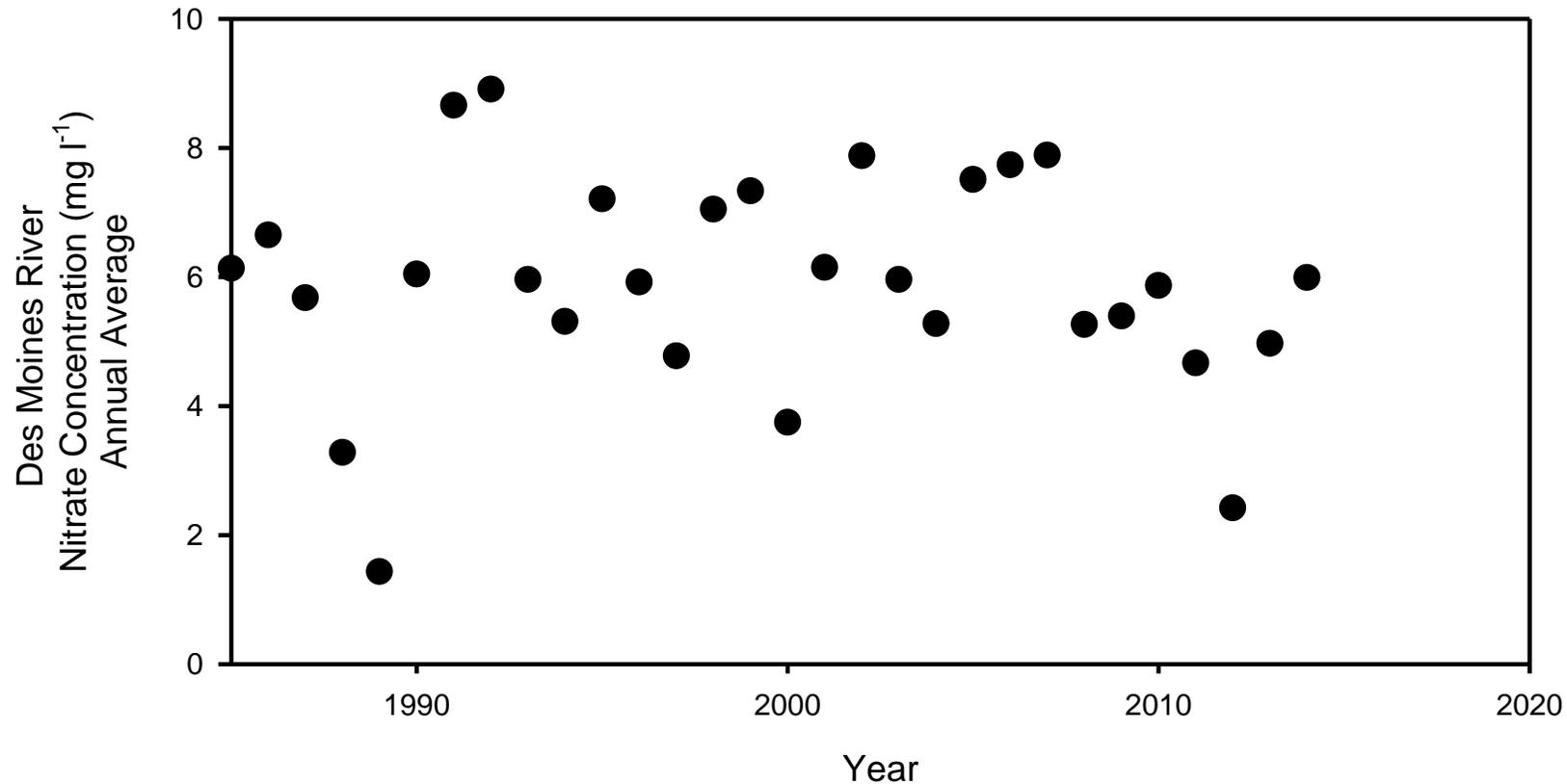
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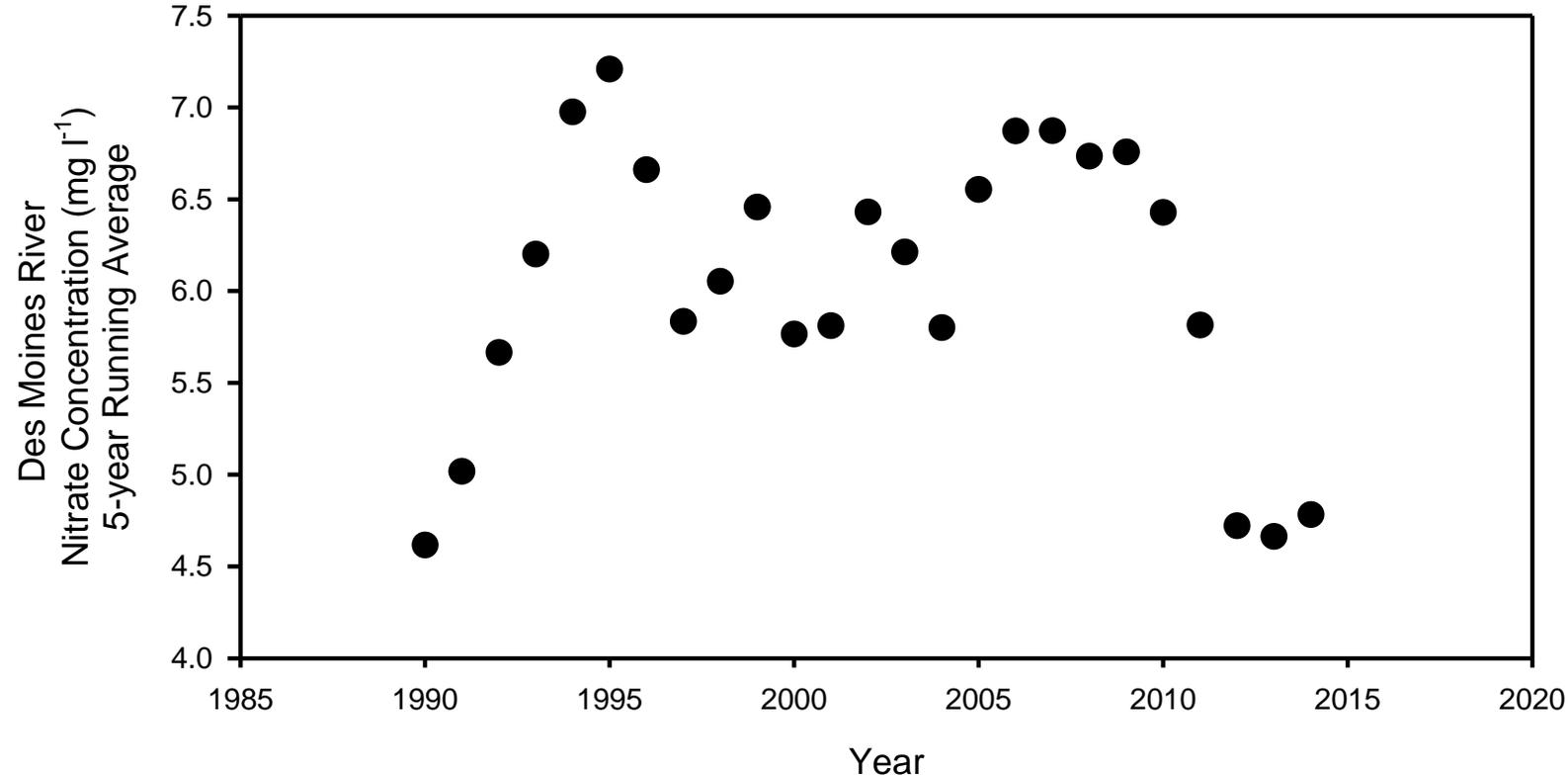
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- 5 year running average of annual average concentration did not change from 1986-2014: 6.0 mg/L SD=0.8 ***5-yr running average displayed below***



Annual concentration reduction to achieve 5, 10, 20 or 43% reduction over 5, 10 or 20 years.

|                 | Percent Concentration Reduction Over the Timeline                              |      |      |      |
|-----------------|--|------|------|------|
|                 | 5%   | 10%  | 20%  | 42%  |
| Timeline        | Annual concentration reduction required to achieve above reductions (mg N/l/y) |      |      |      |
| <b>5 Years</b>  | .075   | .150 | .300 | .630 |
| <b>10 Years</b> | .033   | .066 | .133 | .280 |
| <b>20 Years</b> | .016   | .032 | .063 | .133 |

## Proportion of simulations that measure a significant concentration reduction.

In other words, *power* or the percent chance of measuring a significant reduction if there was actual reduction of 5, 10, 20 or 42%.

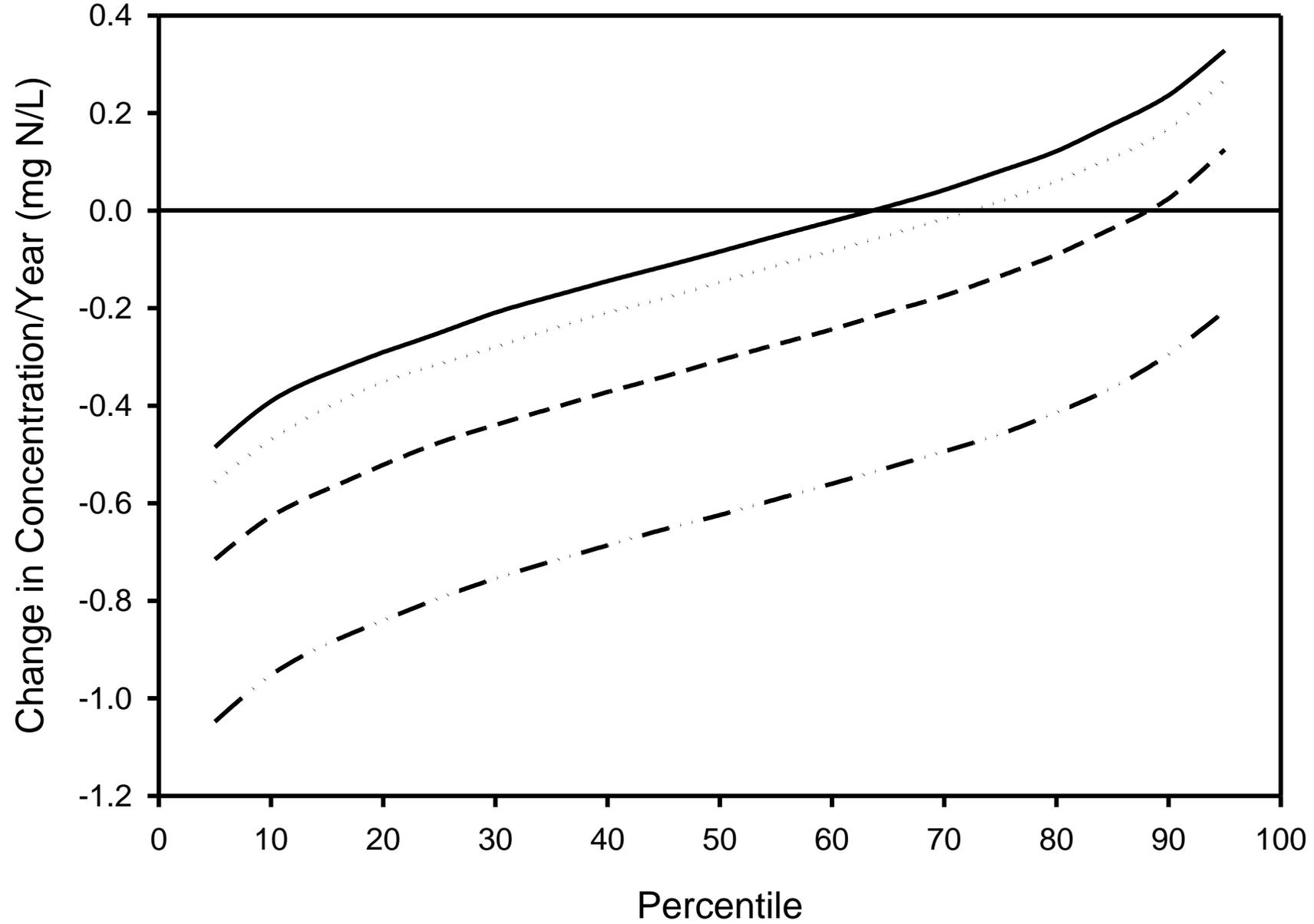
|          | Percent Concentration Reduction Over the Timeline   |      |     |     |
|----------|---|------|-----|-----|
|          | 5%  | 10%  | 20% | 42% |
| Timeline | Proportion of Simulations resulting in a significant ( $p < 0.05$ ) concentration reduction |      |     |     |
| 5 Years  | 4.0%  | 6.0% | 14% | 40% |
| 10 Years | 5.0%  | 10%  | 26% | 79% |
| 20 Years | 7.0%  | 16%  | 49% | 98% |

## Proportion of simulations that measure a decline in conc. (negative slope over time).

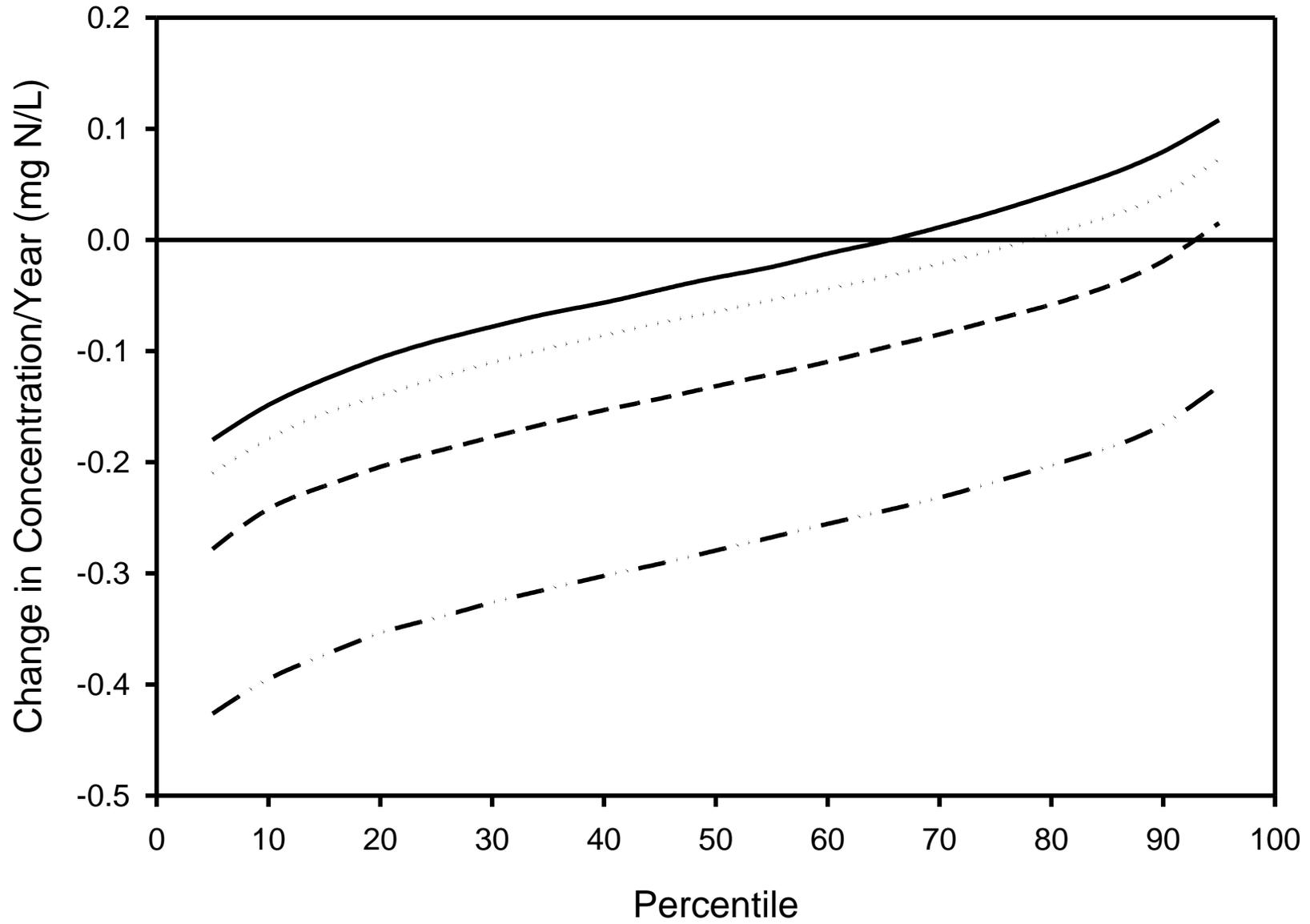
Slope may be significantly or non-significantly negative. In other words, how many simulations produced data with a negative slope? These results, subtracted from the 100% of model runs reveal the proportion of time when an increase would be measured despite the actual reduction in concentration.

|          | Percent Concentration Reduction Over the Timeline   |     |      |      |
|----------|---|-----|------|------|
|          | 5%  | 10% | 20%  | 42%  |
| Timeline | Proportion of simulations that measure a decline in conc. regardless of whether or not decline is significant |     |      |      |
| 5 Years  | 60%   | 70% | 85%  | 100% |
| 10 Years | 60%   | 75% | 90%  | 100% |
| 20 Years | 65%   | 85% | 100% | 100% |

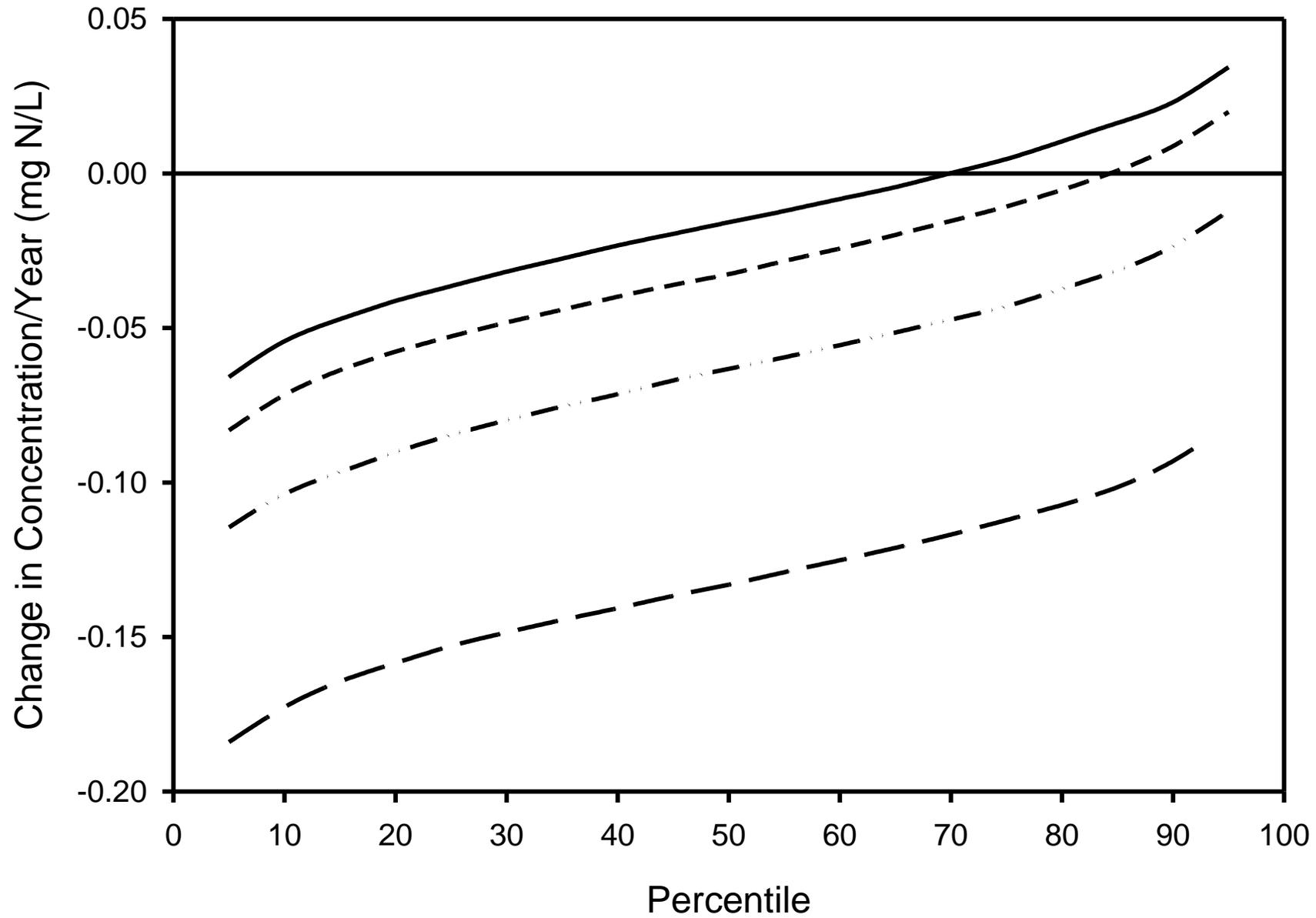
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Percentile distribution of 5, 10, 15, 20, 42% reductions over 10 years



Percentile distribution of 5, 10, 15, 20, 42% reductions over 20 years



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- Chris Jones, Iowa
- Matt Helmers, Iowa State