Data Exploratory Analysis

Data Processing

In [1]:

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import scipy as sp
```

In [2]:

```
data = pd.read_csv("raw_house_data.csv")
data.head()
```

Out[2]:

	MLS	sold_price	zipcode	longitude	latitude	lot_acres	taxes	year_built	bedrooms	ba
0	21530491	5300000.0	85637	-110.378200	31.356362	2154.00	5272.00	1941	13	
1	21529082	4200000.0	85646	-111.045371	31.594213	1707.00	10422.36	1997	2	
2	3054672	4200000.0	85646	-111.040707	31.594844	1707.00	10482.00	1997	2	
3	21919321	4500000.0	85646	-111.035925	31.645878	636.67	8418.58	1930	7	
4	21306357	3411450.0	85750	-110.813768	32.285162	3.21	15393.00	1995	4	

In [3]:

```
data.shape
```

Out[3]:

```
(5000, 16)
```

In [4]:

```
data.columns
```

Out[4]:

```
Index(['MLS', 'sold_price', 'zipcode', 'longitude', 'latitude', 'lot_acres',
       'taxes', 'year_built', 'bedrooms', 'bathrooms', 'sqrt_ft', 'garage',
       'kitchen_features', 'fireplaces', 'floor_covering', 'HOA'],
      dtype='object')
```

In [5]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 16 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   MLS               5000 non-null   int64  
 1   sold_price        5000 non-null   float64
 2   zipcode           5000 non-null   int64  
 3   longitude         5000 non-null   float64
 4   latitude          5000 non-null   float64
 5   lot_acres         4990 non-null   float64
 6   taxes             5000 non-null   float64
 7   year_built        5000 non-null   int64  
 8   bedrooms          5000 non-null   int64  
 9   bathrooms         5000 non-null   object 
 10  sqrt_ft           5000 non-null   object 
 11  garage            5000 non-null   object 
 12  kitchen_features  5000 non-null   object 
 13  fireplaces        5000 non-null   object 
 14  floor_covering    5000 non-null   object 
 15  HOA               5000 non-null   object 
dtypes: float64(5), int64(4), object(7)
memory usage: 625.1+ KB
```

The table above shows that there are 10 missing values in the lot_acres variable. Moreover, there are 7 categorical variables and 9 numerical ones. Let's investigate further into these variables.

In [6]:

```
# numerical variables
numVars = data.select_dtypes(include=np.number).columns.tolist()
# categorical var
catVars = [x for x in data.columns if x not in numVars]
catVars
```

Out[6]:

```
['bathrooms',
 'sqrt_ft',
 'garage',
 'kitchen_features',
 'fireplaces',
 'floor_covering',
 'HOA']
```

In [7]:

```
data[catVars].head()
```

Out[7]:

	bathrooms	sqrt_ft	garage	kitchen_features	fireplaces	floor_covering	HOA
0	10	10500	0	Dishwasher, Freezer, Refrigerator, Oven	6	Mexican Tile, Wood	0
1	2	7300	0	Dishwasher, Garbage Disposal	5	Natural Stone, Other	0
2	3	None	None	Dishwasher, Garbage Disposal, Refrigerator	5	Natural Stone, Other: Rock	None
3	5	9019	4	Dishwasher, Double Sink, Pantry: Butler, Refri...	4	Ceramic Tile, Laminate, Wood	None
4	6	6396	3	Dishwasher, Garbage Disposal, Refrigerator, Mi...	5	Carpet, Concrete	55

bathrooms, sqrt_ft and garage seem more appropriate as numerical variables. Let's investigate these variables.

In [8]:

```
# Unique values of garage variable
data["garage"].unique()
```

Out[8]:

```
array(['0', 'None', '4', '3', '5', '2', '6', '15', '8', '7', '4.5', '3.5',
       '2.5', '1', '9', '22', '30', '12', '10', '11', '20', '13'],
      dtype=object)
```

In [9]:

```
# Unique values of bathroom variable
data["bathrooms"].unique()
```

Out[9]:

```
array(['10', '2', '3', '5', '6', '4', '8', '7', '15', '4.5', '1', '9',
       '11', '18', '14', '3.5', 'None', '35', '2.5', '36'], dtype=object)
```

In [10]:

```
# Unique values of fireplaces variable
data["fireplaces"].unique()
```

Out[10]:

```
array(['6', '5', '4', '1', '2', '3', '7', '0', '9', ' ', '8'],
      dtype=object)
```

In [11]:

```
# Unique values of sqrt_ft variable
data["sqrt_ft"].unique()
```

Out[11]:

```
array(['10500', '7300', 'None', ..., '2106', '3601', '1772'], dtype=object)
```

The unique values of these variables shows that they should be numerical. Furthermore, there are missing values encoded as "None", "", in these variables. We should also handle these missing values later.

In [12]:

```
cat_to_num_vars = ["bathrooms", "garage", "fireplaces", "sqrt_ft"]
```

In [13]:

```
data[numVars].head()
```

Out[13]:

	MLS	sold_price	zipcode	longitude	latitude	lot_acres	taxes	year_built	bedrooms
0	21530491	5300000.0	85637	-110.378200	31.356362	2154.00	5272.00	1941	13
1	21529082	4200000.0	85646	-111.045371	31.594213	1707.00	10422.36	1997	2
2	3054672	4200000.0	85646	-111.040707	31.594844	1707.00	10482.00	1997	2
3	21919321	4500000.0	85646	-111.035925	31.645878	636.67	8418.58	1930	7
4	21306357	3411450.0	85750	-110.813768	32.285162	3.21	15393.00	1995	4

In [14]:

```
data["zipcode"].unique()
```

Out[14]:

```
array([85637, 85646, 85750, 85718, 85712, 85640, 85658, 85739, 85609,
       85755, 86024, 85749, 85715, 85624, 85745, 85742, 85648, 85716,
       85701, 85719, 85641, 85737, 85705, 85743, 85748, 85611, 85704,
       85747, 85614, 85603, 85645, 85602, 85621, 85610, 85615, 85623,
       85622, 85730, 85619, 85629, 85630, 85710, 85643, 86323, 85118,
       85605, 85929, 85711, 85541, 85713, 85625, 85935, 85601, 85901,
       85638, 85192], dtype=int64)
```

In [15]:

```
num_to_cat_vars = ["zipcode"]
```

Although zipcode is encoded numerically, it should be a categorical variables.

In [16]:

```
print("Number of unique values of MLS:")
len(data["MLS"].unique())
```

```
Number of unique values of MLS:
```

Out[16]:

```
5000
```

There are 5000 unique MLS corresponding 5000 observations. It looks like this variable is not very useful as it acts similar to the index. I will drop this variable.

In [17]:

```
numVars1 = numVars + cat_to_num_vars
numVars1.remove("MLS")
numVars1.remove("zipcode")
catVars1 = [x for x in catVars if x not in cat_to_num_vars]
catVars1 = catVars1 + num_to_cat_vars
catVars1
```

Out[17]:

```
['kitchen_features', 'floor_covering', 'HOA', 'zipcode']
```

In [18]:

```
data1 = data[numVars1+catVars1]
data1.head()
```

Out[18]:

	sold_price	longitude	latitude	lot_acres	taxes	year_built	bedrooms	bathrooms	garage	fi
0	5300000.0	-110.378200	31.356362	2154.00	5272.00	1941	13	10	0	
1	4200000.0	-111.045371	31.594213	1707.00	10422.36	1997	2	2	0	
2	4200000.0	-111.040707	31.594844	1707.00	10482.00	1997	2	3	None	
3	4500000.0	-111.035925	31.645878	636.67	8418.58	1930	7	5	4	
4	3411450.0	-110.813768	32.285162	3.21	15393.00	1995	4	6	3	

In [19]:

```
# Convert variables from string to float
```

```
for i in cat_to_num_vars:
    data1[i] = pd.to_numeric(data1[i], errors="coerce")
data1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 15 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   sold_price        5000 non-null   float64
 1   longitude         5000 non-null   float64
 2   latitude          5000 non-null   float64
 3   lot_acres         4990 non-null   float64
 4   taxes             5000 non-null   float64
 5   year_built        5000 non-null   int64  
 6   bedrooms          5000 non-null   int64  
 7   bathrooms         4994 non-null   float64
 8   garage            4993 non-null   float64
 9   fireplaces        4975 non-null   float64
 10  sqrt_ft           4944 non-null   float64
 11  kitchen_features  5000 non-null   object 
 12  floor_covering    5000 non-null   object 
 13  HOA               5000 non-null   object 
 14  zipcode           5000 non-null   int64  
dtypes: float64(9), int64(3), object(3)
memory usage: 586.1+ KB
```

```
<ipython-input-19-9fb82f82fb01>:3: SettingWithCopyWarning: 
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
  data1[i] = pd.to_numeric(data1[i], errors="coerce")
```

Handling Missing Values

In [20]:

```
data1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 15 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   sold_price        5000 non-null   float64
 1   longitude         5000 non-null   float64
 2   latitude          5000 non-null   float64
 3   lot_acres         4990 non-null   float64
 4   taxes             5000 non-null   float64
 5   year_built        5000 non-null   int64  
 6   bedrooms          5000 non-null   int64  
 7   bathrooms         4994 non-null   float64
 8   garage            4993 non-null   float64
 9   fireplaces        4975 non-null   float64
 10  sqrt_ft           4944 non-null   float64
 11  kitchen_features  5000 non-null   object 
 12  floor_covering    5000 non-null   object 
 13  HOA               5000 non-null   object 
 14  zipcode           5000 non-null   int64  
dtypes: float64(9), int64(3), object(3)
memory usage: 586.1+ KB
```

Since there are not a lot of missing values in our numerical dataset, I'll just drop these observations.

In [21]:

```
data2 = data1.dropna()
data2.shape
```

Out[21]:

```
(4940, 15)
```

In [22]:

```
# Categorical Variables
data2[catVars1].head()
```

Out[22]:

	kitchen_features	floor_covering	HOA	zipcode
0	Dishwasher, Freezer, Refrigerator, Oven	Mexican Tile, Wood	0	85637
1	Dishwasher, Garbage Disposal	Natural Stone, Other	0	85646
3	Dishwasher, Double Sink, Pantry: Butler, Refri...	Ceramic Tile, Laminate, Wood	None	85646
4	Dishwasher, Garbage Disposal, Refrigerator, Mi...	Carpet, Concrete	55	85750
5	Dishwasher, Garbage Disposal, Refrigerator, Mi...	Natural Stone, Wood, Other	422	85718

As shown in the table above, there are missing values in these variables encoded as "None". We'll check to see how many missing values are there.

In [23]:

```
catVarsToCheck = [x for x in catVars1 if x != "zipcode"]
for i in catVarsToCheck:
    if i == "zipcode":
        pass
    count = 0
    for idx, val in enumerate(data2[i].values):
        if val == "None":
            count += 1
    print(f"Variable {i}, total number of missing values:", count)
```

```
Variable kitchen_features, total number of missing values: 32
Variable floor_covering, total number of missing values: 0
Variable HOA, total number of missing values: 540
```

HOA is not necessary in a housing unit. Therefore, although the values are encoded as None, it does not mean it is missing. We'll encode these values as -1. For the kitchen variable, I'll remove the missing values.

In [24]:

```
data2["HOA"] = pd.to_numeric(data2["HOA"], errors="coerce")
data2["HOA"].fillna(-1, inplace=True)
data2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 4940 entries, 0 to 4998
Data columns (total 15 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   sold_price        4940 non-null   float64
 1   longitude         4940 non-null   float64
 2   latitude          4940 non-null   float64
 3   lot_acres         4940 non-null   float64
 4   taxes             4940 non-null   float64
 5   year_built        4940 non-null   int64  
 6   bedrooms          4940 non-null   int64  
 7   bathrooms         4940 non-null   float64
 8   garage            4940 non-null   float64
 9   fireplaces        4940 non-null   float64
 10  sqrt_ft           4940 non-null   float64
 11  kitchen_features  4940 non-null   object 
 12  floor_covering    4940 non-null   object 
 13  HOA               4940 non-null   float64
 14  zipcode           4940 non-null   int64  
dtypes: float64(10), int64(3), object(2)
memory usage: 617.5+ KB
```

```
<ipython-input-24-2472eccfdef5>:1: SettingWithCopyWarning: 
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
  data2["HOA"] = pd.to_numeric(data2["HOA"], errors="coerce")
D:\miniconda\envs\jupyter\lib\site-packages\pandas\core\series.py:4460: SettingWithCopyW
arning: 
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
  return super().fillna(
```

In [25]:

```
data2.loc[data2["kitchen_features"] != "None"].shape
```

Out[25]:

```
(4908, 15)
```

In [26]:

```
# Save data to csv file
data2.to_csv("cleaned_raw_house_data.csv")
```

Data Analysis

Dealing with outliers

In [27]:

```
numVarsToPlot = [x for x in numVars1 if x not in ["longitude", "latitude", "year_built"
n_rows = 2
n_cols = len(numVarsToPlot) // 2
count = 0

fig, ax = plt.subplots(n_rows, n_cols, figsize=(12,15))
for idx, var in enumerate(numVarsToPlot):
    plt.subplot(n_rows, n_cols, count+1)
    sns.boxplot(data2[var], orient="vertical")
    count += 1
fig.suptitle("Original Data Box Plots", fontsize=25)
plt.show()
```

```
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pa
ss the following variable as a keyword arg: x. From version 0.12, the only valid positio
nal argument will be `data`, and passing other arguments without an explicit keyword wil
l result in an error or misinterpretation.
  warnings.warn(
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_core.py:1319: UserWarning: Vertical
orientation ignored with only `x` specified.
```

```
  warnings.warn(single_var_warning.format("Vertical", "x"))
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pa
ss the following variable as a keyword arg: x. From version 0.12, the only valid positio
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  warnings.warn(single_var_warning.format("Vertical", "x"))
```

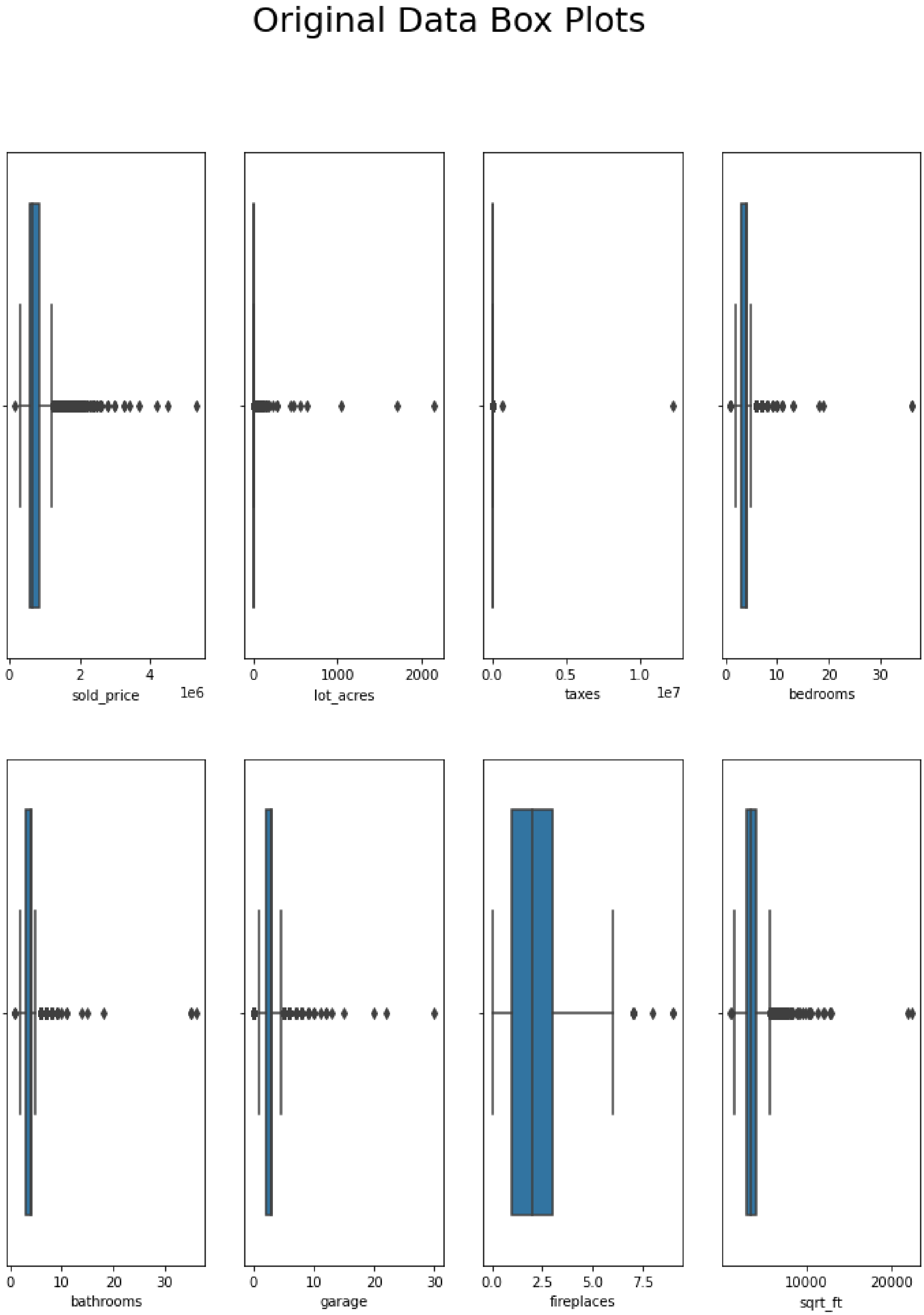

Original Data Box Plots

There are many outliers in our dataset. I will winsorize the data to reduce the effects of the outliers

```
In [28]: data3 = data2.copy()
```

```python
for col in data2[numVarsToPlot].columns:
    data3[col] = sp.stats.mstats.winsorize(data2[col], limits=0.05)
```

In [29]:

```python
# Boxplots of numerical values after winsorizing
n_rows = 2
n_cols = len(numVarsToPlot) // 2
count = 0

fig, ax = plt.subplots(n_rows, n_cols, figsize=(12,15))

for idx, var in enumerate(numVarsToPlot):
    plt.subplot(n_rows, n_cols, count+1)
    sns.boxplot(data3[var], orient="vertical")
    count += 1
fig.suptitle("Winsorized Box Plots", fontsize=25)
plt.show()
```

```
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pa
ss the following variable as a keyword arg: x. From version 0.12, the only valid positio
nal argument will be `data`, and passing other arguments without an explicit keyword wil
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  warnings.warn(
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_core.py:1319: UserWarning: Vertical
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  warnings.warn(single_var_warning.format("Vertical", "x"))
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D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pa
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  warnings.warn(
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  warnings.warn(single_var_warning.format("Vertical", "x"))
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  warnings.warn(
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  warnings.warn(
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  warnings.warn(
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  warnings.warn(single_var_warning.format("Vertical", "x"))
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pa
ss the following variable as a keyword arg: x. From version 0.12, the only valid positio
nal argument will be `data`, and passing other arguments without an explicit keyword wil
l result in an error or misinterpretation.
  warnings.warn(
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_core.py:1319: UserWarning: Vertical
orientation ignored with only `x` specified.
  warnings.warn(single_var_warning.format("Vertical", "x"))
```
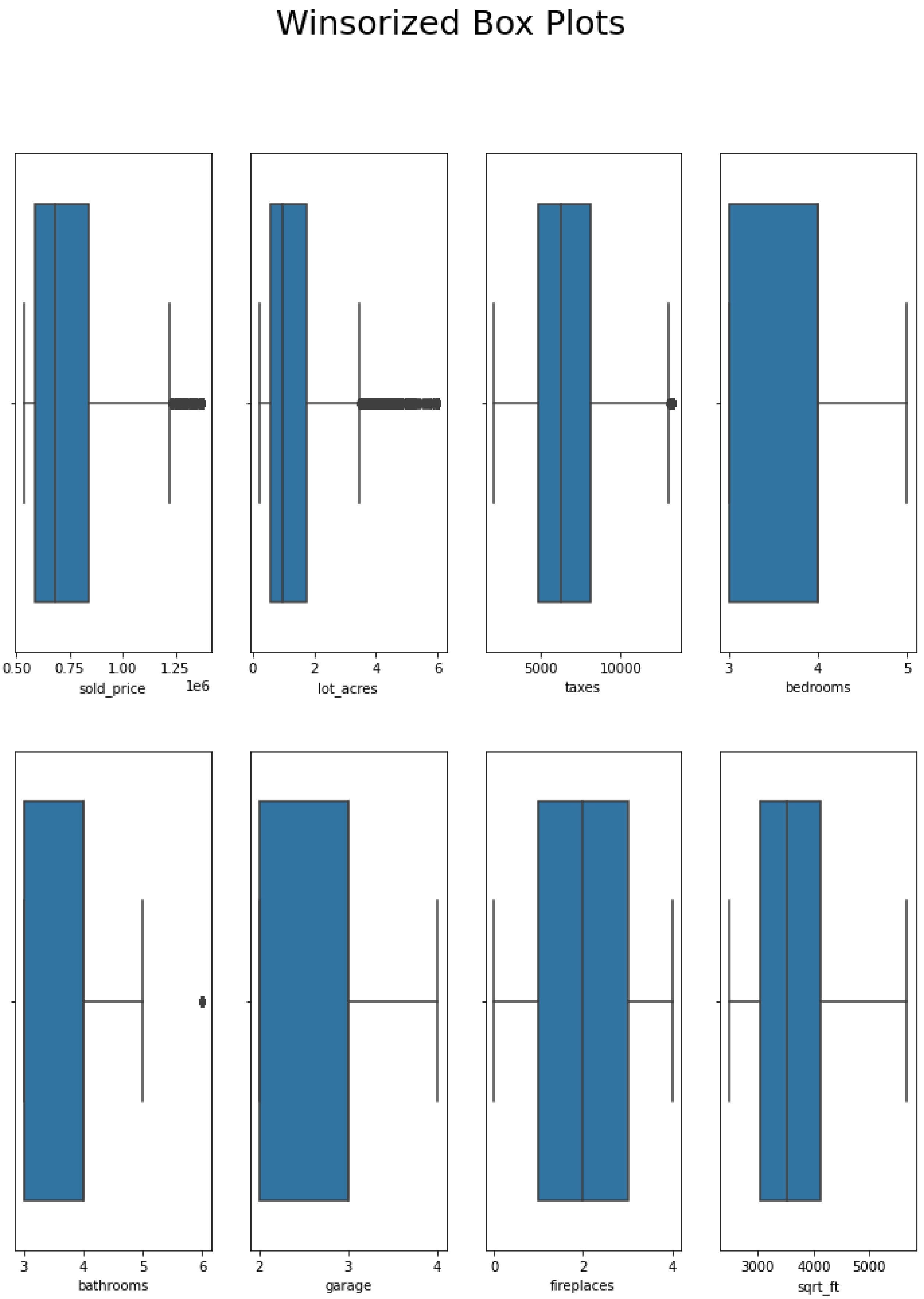



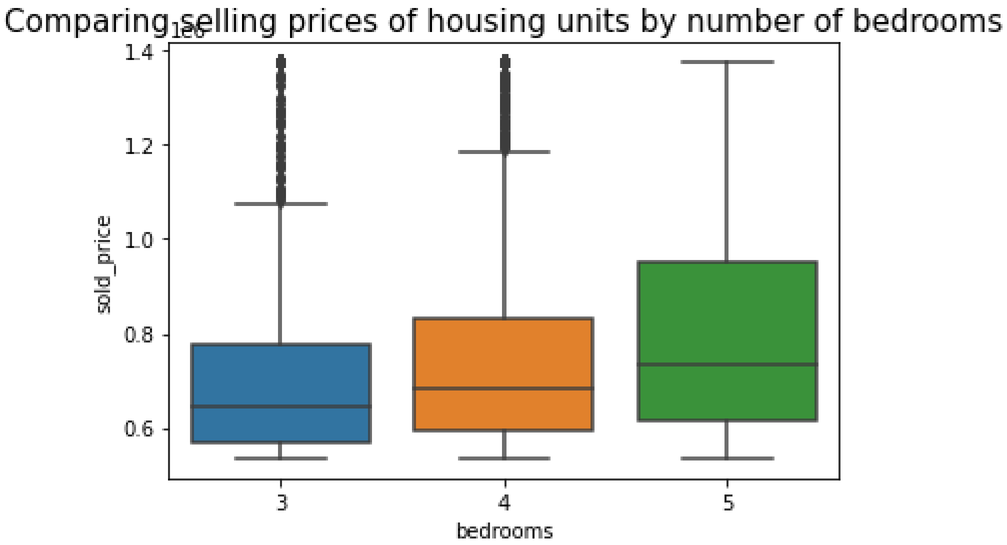
In [30]:
```
data3.to_csv("Final_cleaned_data.csv")
```

In [31]:

```
sns.boxplot(x="bedrooms", y="sold_price", data=data3).set_title("Comparing selling pric
```

Out[31]:

```
Text(0.5, 1.0, 'Comparing selling prices of housing units by number of bedrooms')
```

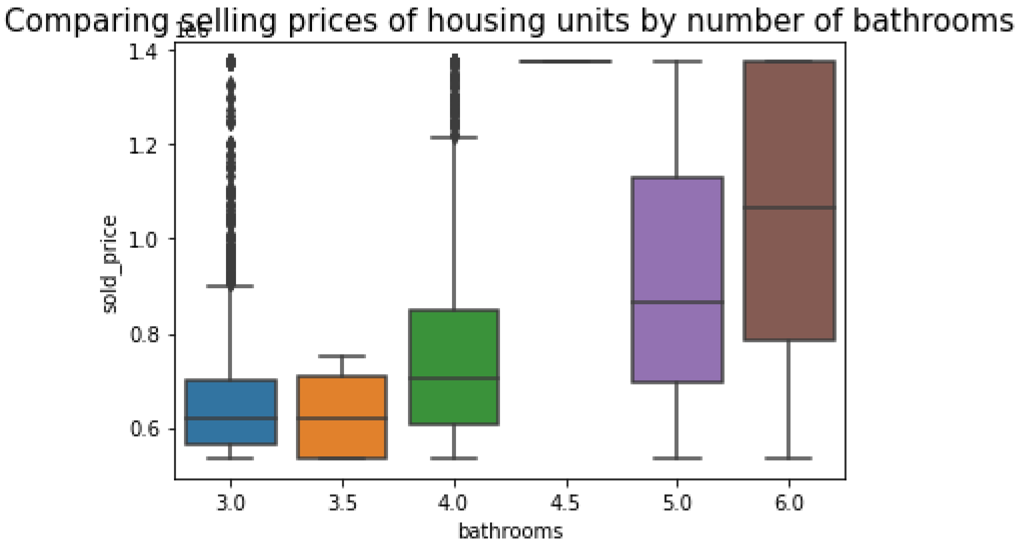


In [32]:

```
sns.boxplot(x="bathrooms", y="sold_price", data=data3).set_title("Comparing selling pri
```

Out[32]:

```
Text(0.5, 1.0, 'Comparing selling prices of housing units by number of bathrooms')
```

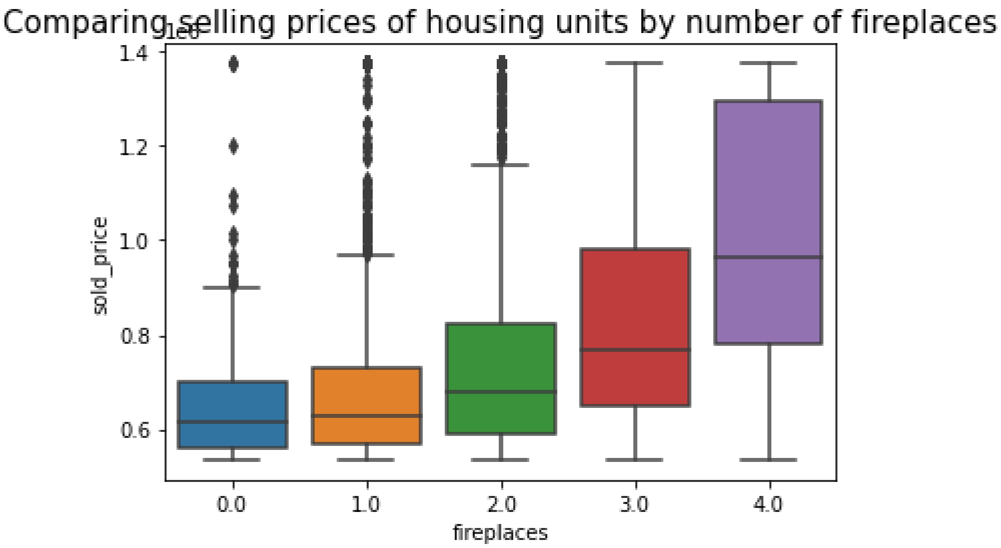


In [33]:

```
sns.boxplot(x="fireplaces", y="sold_price", data=data3).set_title("Comparing selling pr
```

Out[33]:

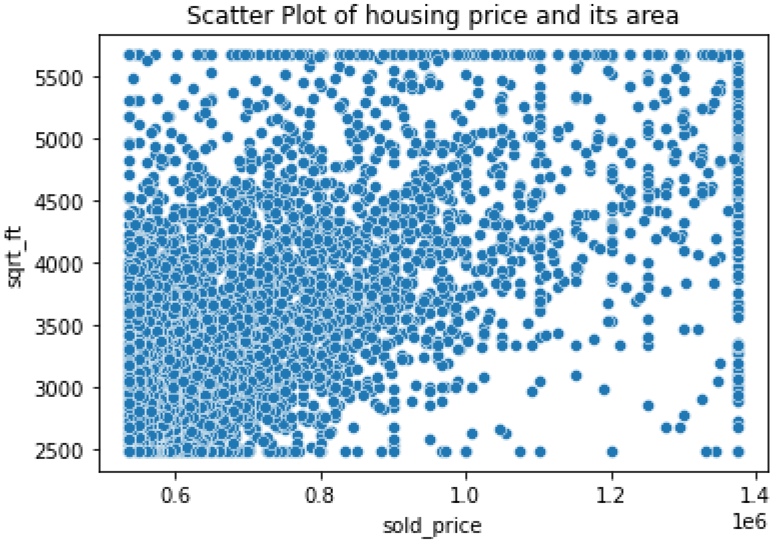
```
Text(0.5, 1.0, 'Comparing selling prices of housing units by number of fireplaces')
```



```
In [34]: sns.scatterplot("sold_price", "sqrt_ft", data=data3).set_title("Scatter Plot of housing
```

```
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pa
ss the following variables as keyword args: x, y. From version 0.12, the only valid posi
tional argument will be `data`, and passing other arguments without an explicit keyword
will result in an error or misinterpretation.
  warnings.warn(
```

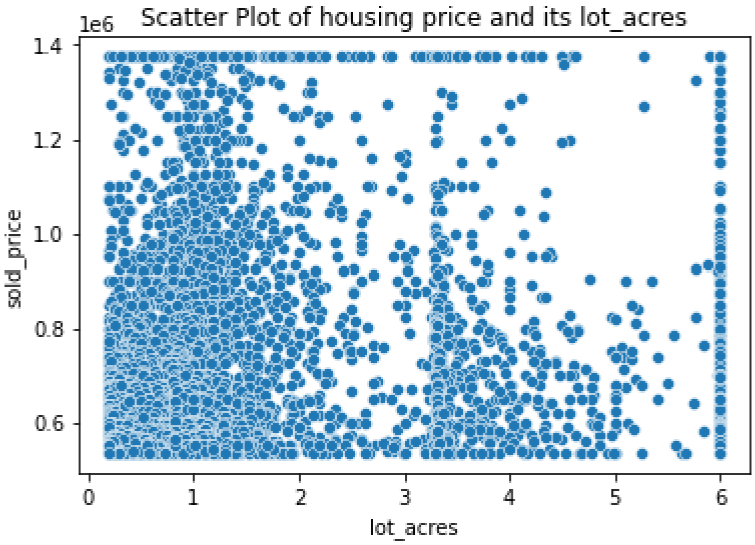
```
Out[34]: Text(0.5, 1.0, 'Scatter Plot of housing price and its area')
```



```
In [35]: sns.scatterplot("lot_acres", "sold_price", data=data3).set_title("Scatter Plot of housi
```

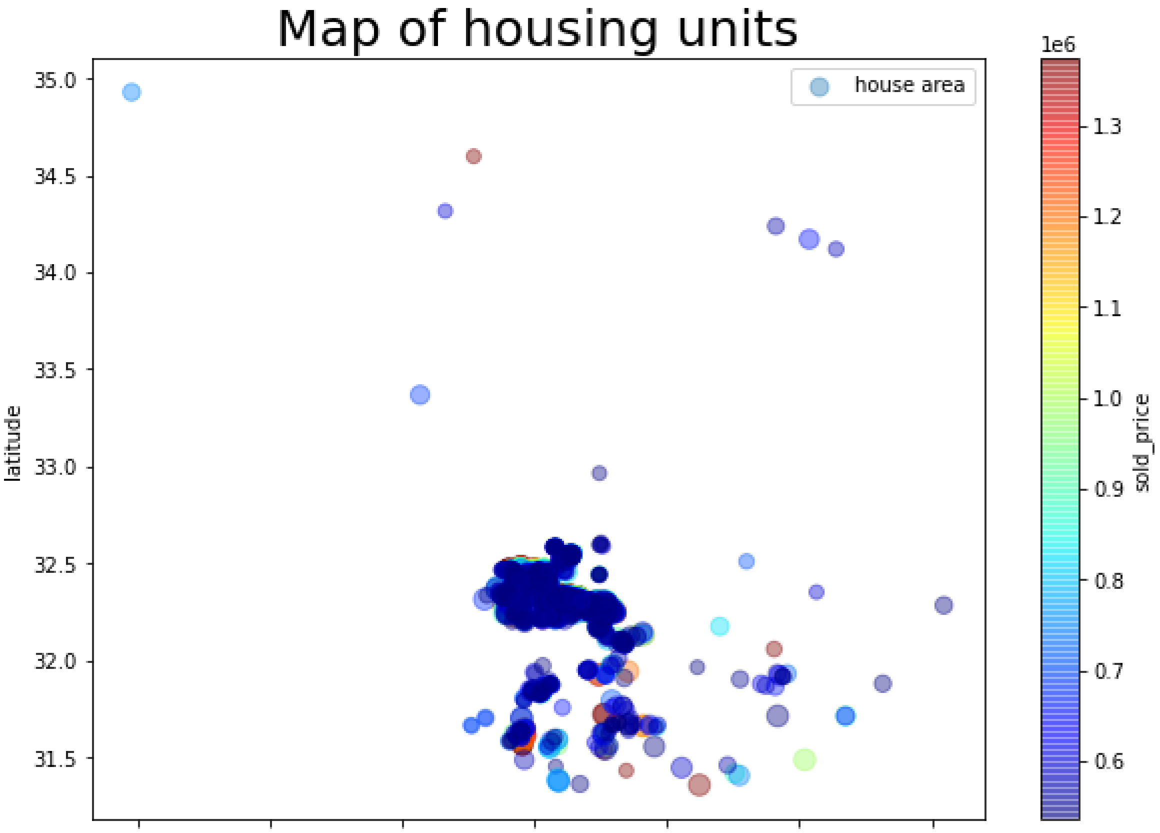
```
D:\miniconda\envs\jupyter\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pa
ss the following variables as keyword args: x, y. From version 0.12, the only valid posi
tional argument will be `data`, and passing other arguments without an explicit keyword
will result in an error or misinterpretation.
  warnings.warn(
```

```
Out[35]: Text(0.5, 1.0, 'Scatter Plot of housing price and its lot_acres')
```



In [36]:

```
data3.plot(kind="scatter", x="longitude", y="latitude",
    s=data3['sqrt_ft']/50, label="house area",
    c="sold_price", cmap=plt.get_cmap("jet"),
    colorbar=True, alpha=0.4, figsize=(10,7),
)
plt.title("Map of housing units", fontsize=25)
plt.legend()
plt.show()
```



In [ ]: