Bird: Mourning Dove

In [ ]:
```python
import pandas as pd

df = pd.read_csv("mourningdove.csv")
df
```

Out[ ]:

| | Country | State | Route | Year | Aou | SpeciesTotal |
|---|---|---|---|---|---|---|
| **0** | 124.0 | 4.0 | 1.0 | 1990.0 | 3160.0 | 7.0 |
| **1** | 124.0 | 4.0 | 1.0 | 1991.0 | 3160.0 | 32.0 |
| **2** | 124.0 | 4.0 | 1.0 | 1992.0 | 3160.0 | 1.0 |
| **3** | 124.0 | 4.0 | 1.0 | 1993.0 | 3160.0 | 2.0 |
| **4** | 124.0 | 4.0 | 1.0 | 1994.0 | 3160.0 | 5.0 |
| **...** | ... | ... | ... | ... | ... | ... |
| **76660** | 840.0 | 92.0 | 901.0 | 2018.0 | 3160.0 | 1.0 |
| **76661** | 840.0 | 92.0 | 902.0 | 2004.0 | 3160.0 | 25.0 |
| **76662** | 840.0 | 92.0 | 902.0 | 2006.0 | 3160.0 | 13.0 |
| **76663** | 840.0 | 92.0 | 902.0 | 2015.0 | 3160.0 | 2.0 |
| **76664** | 840.0 | 92.0 | 902.0 | 2017.0 | 3160.0 | 6.0 |

76665 rows × 6 columns

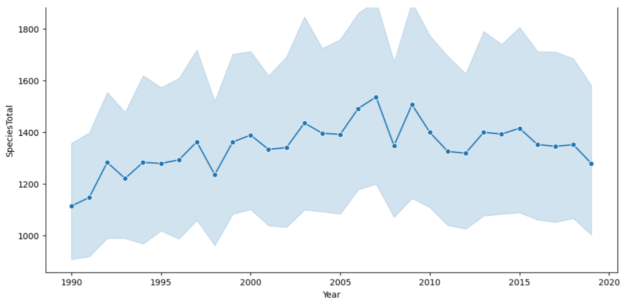
In [ ]:
```python
# Grouping by State, ignoring individual routes and aggregating them to stat

df_grouped = df.groupby(['State', 'Year'], as_index=False)['SpeciesTotal'].s
df_grouped
```

Out[ ]:

| | State | Year | SpeciesTotal |
|---|---|---|---|
| **0** | 2.0 | 1990.0 | 1891.0 |
| **1** | 2.0 | 1991.0 | 1802.0 |
| **2** | 2.0 | 1992.0 | 1776.0 |
| **3** | 2.0 | 1993.0 | 2127.0 |
| **4** | 2.0 | 1994.0 | 2098.0 |
| **...** | ... | ... | ... |
| **1720** | 92.0 | 2016.0 | 906.0 |
| **1721** | 92.0 | 2017.0 | 795.0 |
| **1722** | 92.0 | 2018.0 | 771.0 |
| **1723** | 92.0 | 2019.0 | 519.0 |
| **1724** | 93.0 | 1994.0 | 1.0 |

1725 rows × 3 columns

In [ ]:
```python
# Visualizing our data

import seaborn as sns
import matplotlib.pyplot as plt

plt.figure(figsize=(12,6))
sns.lineplot(data=df_grouped, x="Year", y="SpeciesTotal", marker="o")

plt.title("Species Sightings for Mourning Dove in the US", fontsize=12)
plt.xlabel("Year", fontsize=10)
plt.ylabel("SpeciesTotal", fontsize=10)

plt.show()
```




In [ ]:
```
df_grouped["State"].unique()
```

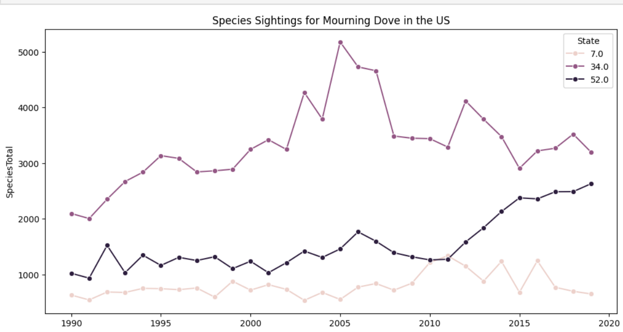
Out[ ]:
```
array([ 2.,  4.,  6.,  7., 11., 14., 17., 18., 21., 25., 27., 33., 34.,
       35., 36., 38., 39., 42., 44., 45., 46., 47., 49., 50., 51., 52.,
       53., 54., 55., 56., 57., 58., 59., 60., 61., 63., 64., 65., 66.,
       67., 68., 69., 72., 75., 76., 77., 79., 80., 81., 82., 83., 85.,
       87., 88., 89., 90., 91., 92., 93.])
```

The metadata defines each state:

''' 02,Alabama; 03,Alaska; 04,Alberta; 06,Arizona; 07,Arkansas; 11,British Columbia; 14,California; 17,Colorado; 18,Connecticut; 21,Delaware; 25,Florida; 27,Georgia; 33,Idaho; 34,Illinois; 35,Indiana; 36,Iowa; 38,Kansas; 39,Kentucky; 42,Louisiana; 43,Northwest Territories; 44,Maine; 45,Manitoba; 46,Maryland; 47,Massachusetts; 49,Michigan; 50,Minnesota; 51,Mississippi; 52,Missouri; 53,Montana; 54,Nebraska; 55,Nevada; 56,New Brunswick; 57,Newfoundland and Labrador; 58,New Hampshire; 59,New Jersey; 60,New Mexico; 61,New York; 62,Nunavut; 63,North Carolina; 64,North Dakota; 65,Nova Scotia; 66,Ohio; 67,Oklahoma; 68,Ontario; 69,Oregon; 72,Pennsylvania; 75,Prince Edward Island; 76,Quebec; 77,Rhode Island; 79,Saskatchewan; 80,South Carolina; 81,South Dakota; 82,Tennessee; 83,Texas; 85,Utah; 87,Vermont; 88,Virginia; 89,Washington; 90,West Virginia; 91,Wisconsin; 92,Wyoming; 93,Yukon '''

We will use, for now, 07 Arkansas, 34 Illinois, 52 Missouri.

In [ ]:
```
# Visualizing our data

import seaborn as sns
import matplotlib.pyplot as plt

df_filtered = df_grouped[df_grouped["State"].isin([7,34,52])]

plt.figure(figsize=(12,6))
sns.lineplot(data=df_filtered, x="Year", y="SpeciesTotal", hue="State", mark

plt.title("Species Sightings for Mourning Dove in the US", fontsize=12)
plt.xlabel("Year", fontsize=10)
plt.ylabel("SpeciesTotal", fontsize=10)
plt.show()
```




In [ ]:
```
df_filtered
```

Out[ ]:

| | State | Year | SpeciesTotal |
|---|---|---|---|
| **90** | 7.0 | 1990.0 | 629.0 |
| **91** | 7.0 | 1991.0 | 542.0 |

| | | | |
|---|---|---|---|
| **92** | 7.0 | 1992.0 | 684.0 |
| **93** | 7.0 | 1993.0 | 676.0 |
| **94** | 7.0 | 1994.0 | 750.0 |
| **...** | ... | ... | ... |
| **775** | 52.0 | 2015.0 | 2376.0 |
| **776** | 52.0 | 2016.0 | 2358.0 |
| **777** | 52.0 | 2017.0 | 2486.0 |
| **778** | 52.0 | 2018.0 | 2488.0 |
| **779** | 52.0 | 2019.0 | 2631.0 |

90 rows × 3 columns

Now comparing with emission types

In [ ]:

```
import pandas as pd

df_emissions = pd.read_csv("full_data.csv")

states = {
    'Arkansas': 7,
    'Illinois': 34,
    'Missouri': 52
}

df_emissions.rename(columns={'Region': 'State', 'Value': 'Emissions'}, inpla
df_emissions['State'] = df_emissions['State'].map(states)
df_emissions = df_emissions[df_emissions["State"].isin([7, 34, 52])]

df_emissions_pivoted = df_emissions.pivot_table(index=['State', 'Year'], col
df_emissions_pivoted.columns = [col for col in df_emissions_pivoted.columns]
df_emissions_pivoted.reset_index(inplace=True)
df_combined = pd.merge(df_filtered, df_emissions_pivoted, on=['State', 'Year
df_combined = df_combined.drop(columns=['Gross total', 'Net total'])

(df_combined)
```

Out[ ]:

| | State | Year | SpeciesTotal | Carbon dioxide | Fluorinated gases | Land use and forestry carbon stock change | Methane | Nitrous oxide |
|---|---|---|---|---|---|---|---|---|
| **0** | 7.0 | 1990.0 | 629.0 | 54.132545 | 1.786645 | -54.692963 | 19.292660 | 6.820905 |
| **1** | 7.0 | 1991.0 | 542.0 | 52.856844 | 1.774128 | -53.677058 | 20.753636 | 6.932789 |
| **2** | 7.0 | 1992.0 | 684.0 | 54.872688 | 1.784589 | -53.177882 | 19.099499 | 7.071014 |
| **3** | 7.0 | 1993.0 | 676.0 | 53.910021 | 1.821897 | -52.455692 | 19.912666 | 7.185217 |
| **4** | 7.0 | 1994.0 | 750.0 | 57.663686 | 1.931176 | -51.678457 | 20.257696 | 7.031927 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... |
| **85** | 52.0 | 2015.0 | 2376.0 | 131.141261 | 3.751684 | -24.649114 | 13.959973 | 16.166956 |
| **86** | 52.0 | 2016.0 | 2358.0 | 124.714462 | 3.251369 | -23.865313 | 14.543042 | 14.071274 |
| **87** | 52.0 | 2017.0 | 2486.0 | 130.783979 | 3.384542 | -23.793008 | 14.902632 | 15.683796 |
| **88** | 52.0 | 2018.0 | 2488.0 | 131.588221 | 3.078250 | -24.213457 | 15.575442 | 16.136778 |
| **89** | 52.0 | 2019.0 | 2631.0 | 123.542202 | 3.249534 | -22.699114 | 15.095425 | 14.753059 |

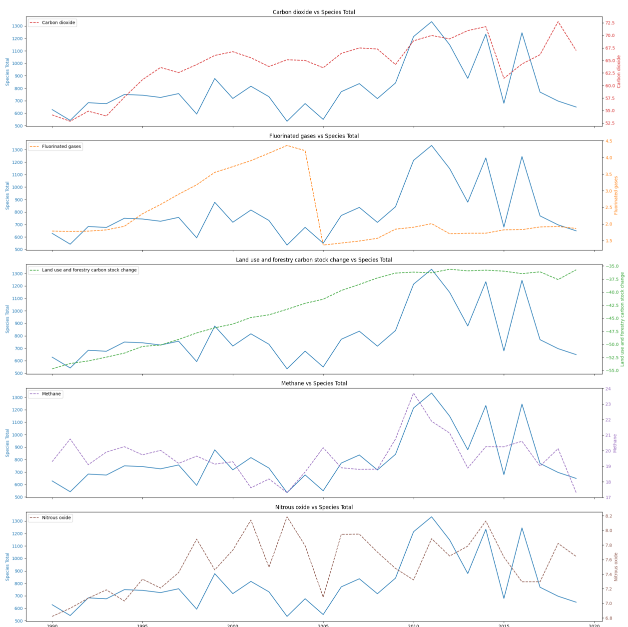
90 rows × 8 columns

Let's look at one state. We choose Arkansas for now.

In [ ]:

```
import matplotlib.pyplot as plt

# Arkansas
state_data = df_combined[df_combined['State'] == 7]

fig, axes = plt.subplots(5, 1, figsize=(20, 20), sharex=True)
```

```python
emission_types = ['Carbon dioxide', 'Fluorinated gases', 'Land use and fores
                  'Methane', 'Nitrous oxide']
colors = ['tab:red', 'tab:orange', 'tab:green', 'tab:purple', 'tab:brown']

for i, emission in enumerate(emission_types):
    ax = axes[i]

    # species
    ax.set_ylabel('Species Total', color='tab:blue')
    ax.plot(state_data['Year'], state_data['SpeciesTotal'], color='tab:blue'

    # emission type
    ax2 = ax.twinx()
    ax2.set_ylabel(emission, color=colors[i])
    ax2.plot(state_data['Year'], state_data[emission], color=colors[i], labe

    # key
    ax.set_title(f'{emission} vs Species Total')
    ax.tick_params(axis='y', labelcolor='tab:blue')
    ax2.tick_params(axis='y', labelcolor=colors[i])
    ax2.legend(loc='upper left')

fig.tight_layout()
plt.xlabel('Year')
plt.show()
```




In [ ]:
```python
correlation_matrix = df_combined[['SpeciesTotal', 'Carbon dioxide', 'Fluorir
                                  'Land use and forestry carbon stock change
correlation_matrix
```

Out[ ]:

| | SpeciesTotal | Carbon dioxide | Fluorinated gases | Land use and forestry carbon stock change | Methane | Nitrous oxide |
|---|---|---|---|---|---|---|
| **SpeciesTotal** | 1.000000 | 0.915412 | 0.815209 | 0.814000 | 0.372454 | 0.873839 |
| **Carbon dioxide** | 0.915412 | 1.000000 | 0.858797 | 0.917618 | 0.430775 | 0.971450 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Fluorinated gases** | 0.815209 | 0.858797 | 1.000000 | 0.711549 | 0.603259 | 0.794049 |
| **Land use and forestry carbon stock change** | 0.814000 | 0.917618 | 0.711549 | 1.000000 | 0.378159 | 0.936623 |
| **Methane** | 0.372454 | 0.430775 | 0.603259 | 0.378159 | 1.000000 | 0.382065 |
| **Nitrous oxide** | 0.873839 | 0.971450 | 0.794049 | 0.936623 | 0.382065 | 1.000000 |

In [ ]:

```
import statsmodels.api as sm

X = df_combined[['Carbon dioxide', 'Fluorinated gases', 'Land use and forest
X = sm.add_constant(X)
y = df_combined['SpeciesTotal_transformed']

# regression model
model = sm.OLS(y, X).fit()
print(model.summary())
```

```
                                OLS Regression Results
============================================================================
=========
Dep. Variable:     SpeciesTotal_transformed   R-squared:
0.850
Model:                                  OLS   Adj. R-squared:
0.845
Method:                       Least Squares   F-statistic:
163.2
Date:                      Sun, 13 Apr 2025   Prob (F-statistic):
1.80e-57
Time:                              15:59:32   Log-Likelihood:
22.300
No. Observations:                       150   AIC:
-32.60
Df Residuals:                           144   BIC:
-14.54
Df Model:                                 5
Covariance Type:                  nonrobust
============================================================================
==================================
                                               coef    std err          t
P>|t|      [0.025      0.975]
----------------------------------------------------------------------------
----------------------------------
const                                        6.7145      0.222     30.307
0.000       6.277       7.152
Carbon dioxide                               0.0070      0.001      8.854
0.000       0.005       0.009
Fluorinated gases                           -0.0181      0.004     -4.071
0.000      -0.027      -0.009
Land use and forestry carbon stock change    0.0124      0.004      3.202
0.002       0.005       0.020
Methane                                     -0.0029      0.005     -0.572
0.568      -0.013       0.007
Nitrous oxide                                0.0106      0.007      1.512
0.133      -0.003       0.025
============================================================================
===
Omnibus:                        0.394   Durbin-Watson:                   0.
833
Prob(Omnibus):                  0.821   Jarque-Bera (JB):                0.
547
Skew:                           0.083   Prob(JB):                        0.
761
Kurtosis:                       2.755   Cond. No.                     1.90e
+03
============================================================================
===

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is corr
ectly specified.
[2] The condition number is large, 1.9e+03. This might indicate that there
are
strong multicollinearity or other numerical problems.
```

In [ ]:

```
from sklearn.model_selection import cross_val_score, KFold
from sklearn.linear_model import LinearRegression
from sklearn.metrics import make_scorer, mean_squared_error
import numpy as np

df_train = df_combined[df_combined['State'].isin([7, 34, 52])]

features = ['Carbon dioxide', 'Fluorinated gases', 'Land use and forestry ca
X_train = df_train[features]
y_train = df_train['SpeciesTotal']

model = LinearRegression()

cv = KFold(n_splits=5, shuffle=True, random_state=1)

r2_scores = cross_val_score(model, X_train, y_train, cv=cv, scoring='r2')

print("Cross-validated R² scores:", np.round(r2_scores, 4))
print("Average R²:", np.round(np.mean(r2_scores), 4))
```

```
Cross-validated R² scores: [0.7801 0.798  0.8297 0.8017 0.6416]
Average R²: 0.7702
```