PANDAS FOUNDATIONS

Indexing time series

Using pandas to read datetime objects

- read_csv() function
  - Can read strings into datetime objects
  - Need to specify 'parse_dates=True'
- ISO 8601 format
  - yyyy-mm-dd hh:mm:ss

Product sales CSV

	Date	Company	Product	Units
0	2015-02-02 08:30:00	Hooli	Software	3
1	2015-02-02 21:00:00	Mediacore	Hardware	9
2	2015-02-03 14:00:00	Initech	Software	13
3	2015-02-04 15:30:00	Streeplex	Software	13
4	2015-02-04 22:00:00	Acme Coporation	Hardware	14

Parse dates

```
In [1]: import pandas as pd

In [2]: sales = pd.read_csv('sales-feb-2015.csv',
   ...:                     parse_dates=True, index_col= 'Date')
```

Parse dates

```
In [3]: sales.head()
Out[3]:
                                Company   Product  Units
Date
2015-02-02 08:30:00               Hooli  Software      3
2015-02-02 21:00:00           Mediacore  Hardware      9
2015-02-03 14:00:00             Initech  Software     13
2015-02-04 15:30:00           Streeplex  Software     13
2015-02-04 22:00:00    Acme Coporation  Hardware     14
```

Parse dates

```
In [4]: sales.info()
DatetimeIndex: 19 entries, 2015-02-02 08:30:00 to 2015-02-26
09:00:00
Data columns (total 3 columns):
Company     19 non-null object
Product     19 non-null object
Units       19 non-null int64
dtypes: int64(1), object(2)
memory usage: 608.0+ bytes
```

Selecting single datetime

```
In [5]: sales.loc['2015-02-19 11:00:00', 'Company']
Out[5]: ‘Mediacore’
```

Selecting whole day

```
In [6]: sales.loc['2015-2-5']
Out[6]:
                              Company   Product  Units
Date
2015-02-05 02:00:00  Acme Coporation  Software     19
2015-02-05 22:00:00            Hooli   Service     10
```

Partial datetime string selection

- Alternative formats:
  - sales.loc['February 5, 2015']
  - sales.loc['2015-Feb-5']
- Whole month: sales.loc['2015-2']
- Whole year: sales.loc['2015']

Selecting whole month

```
In [7]: sales.loc['2015-2']
Out[7]:
                               Company   Product  Units
Date
2015-02-02 08:30:00              Hooli  Software      3
2015-02-02 21:00:00          Mediacore  Hardware      9
2015-02-03 14:00:00            Initech  Software     13
2015-02-04 15:30:00          Streeplex  Software     13
2015-02-04 22:00:00   Acme Coporation  Hardware     14
2015-02-05 02:00:00   Acme Coporation  Software     19
2015-02-05 22:00:00              Hooli   Service     10
2015-02-07 23:00:00   Acme Coporation  Hardware      1
2015-02-09 09:00:00          Streeplex   Service     19
2015-02-09 13:00:00          Mediacore  Software      7
2015-02-11 20:00:00            Initech  Software      7
2015-02-11 23:00:00              Hooli  Software      4
2015-02-16 12:00:00              Hooli  Software     10
2015-02-19 11:00:00          Mediacore  Hardware     16
…
```

Slicing using dates/times

```
In [8]: sales.loc['2015-2-16':'2015-2-20']
Out[8]:
                       Company   Product  Units
Date
2015-02-16 12:00:00      Hooli  Software     10
2015-02-19 11:00:00  Mediacore  Hardware     16
2015-02-19 16:00:00  Mediacore   Service     10
```

Convert strings to datetime

```
In [9]: evening_2_11 = pd.to_datetime(['2015-2-11 20:00',
   ...: '2015-2-11 21:00', '2015-2-11 22:00', '2015-2-11 23:00'])

In [10]: evening_2_11
Out[10]:
DatetimeIndex(['2015-02-11 20:00:00', '2015-02-11 21:00:00',
               '2015-02-11 22:00:00', '2015-02-11 23:00:00'],
              dtype='datetime64[ns]', freq=None)
```

Reindexing DataFrame

```
In [11]: sales.reindex(evening_2_11)
Out[11]:
                    Company   Product  Units
2015-02-11 20:00:00 Initech  Software    7.0
2015-02-11 21:00:00     NaN       NaN    NaN
2015-02-11 22:00:00     NaN       NaN    NaN
2015-02-11 23:00:00   Hooli  Software    4.0
```

Filling missing values

```
In [12]: sales.reindex(evening_2_11, method='ffill')
Out[12]:
                    Company   Product  Units
2015-02-11 20:00:00 Initech  Software      7
2015-02-11 21:00:00 Initech  Software      7
2015-02-11 22:00:00 Initech  Software      7
2015-02-11 23:00:00   Hooli  Software      4

In [13]: sales.reindex(evening_2_11, method='bfill')
Out[13]:
                    Company   Product  Units
2015-02-11 20:00:00 Initech  Software      7
2015-02-11 21:00:00   Hooli  Software      4
2015-02-11 22:00:00   Hooli  Software      4
2015-02-11 23:00:00   Hooli  Software      4
```

Let’s practice!

PANDAS FOUNDATIONS

Resampling time series data

Sales data

```
In [1]: import pandas as pd

In [2]: sales = pd.read_csv('sales-feb-2015.csv',
   ...:                     parse_dates=True, index_col= 'Date')

In [3]: sales.head()
Out[3]:
                             Company   Product  Units
Date
2015-02-02 08:30:00            Hooli  Software      3
2015-02-02 21:00:00        Mediacore  Hardware      9
2015-02-03 14:00:00          Initech  Software     13
2015-02-04 15:30:00        Streeplex  Software     13
2015-02-04 22:00:00  Acme Coporation  Hardware     14
```

Resampling

- Statistical methods over different time intervals
  - mean(), sum(), count(), etc.
- Down-sampling
  - reduce datetime rows to slower frequency
- Up-sampling
  - increase datetime rows to faster frequency

Aggregating means

```
In [4]: daily_mean = sales.resample('D').mean()

In [5]: daily_mean
Out[5]:
            Units
Date
2015-02-02    6.0
2015-02-03   13.0
2015-02-04   13.5
2015-02-05   14.5
2015-02-06    NaN
2015-02-07    1.0
2015-02-08    NaN
2015-02-09   13.0
2015-02-10    NaN
2015-02-11    5.5
2015-02-12    NaN
2015-02-13    NaN
2015-02-14    NaN
```

Verifying

```
In [6]: print(daily_mean.loc['2015-2-2'])
Units    6.0
Name: 2015-02-02 00:00:00, dtype: float64

In [7]: print(sales.loc['2015-2-2', 'Units'])
Date
2015-02-02 08:30:00    3
2015-02-02 21:00:00    9
Name: Units, dtype: int64

In [8]: sales.loc['2015-2-2', 'Units'].mean()
Out[8]: 6.0
```

Method chaining

```
In [9]: sales.resample('D').sum()
Out[9]:
            Units
Date
2015-02-02    6.0
2015-02-03   13.0
2015-02-04   13.5
2015-02-05   14.5
2015-02-06    NaN
2015-02-07    1.0
2015-02-08    NaN
2015-02-09   13.0
2015-02-10    NaN
2015-02-11    5.5
2015-02-12    NaN
2015-02-13    NaN
```

Method chaining

```
In [10]: sales.resample('D').sum().max()
Out[10]:
Units    29.0
dtype: float64
```

Resampling strings

```
In [11]: sales.resample('W').count()
Out[11]:
            Company  Product  Units
Date
2015-02-08        8        8      8
2015-02-15        4        4      4
2015-02-22        5        5      5
2015-03-01        2        2      2
```

Resampling frequencies

Input	Description
‘min’, ‘ T’	minute
‘H’	hour
‘D’	day
‘B’	business day
‘W’	week
‘M’	month
‘Q’	quarter
‘A’	year

Multiplying frequencies

```
In [12]: sales.loc[:,'Units'].resample('2W').sum()
Out[12]:
Date
2015-02-08    82
2015-02-22    79
2015-03-08    14
Freq: 2W-SUN, Name: Units, dtype: int64
```

Upsampling

```
In [13]: two_days = sales.loc['2015-2-4': '2015-2-5', 'Units']

In [13]: two_days
Out[13]:
Date
2015-02-04 15:30:00    13
2015-02-04 22:00:00    14
2015-02-05 02:00:00    19
2015-02-05 22:00:00    10
Name: Units, dtype: int64
```

Upsampling and filling

```
In [14]: two_days.resample('4H').ffill()
Out[14]:
Date
Date
2015-02-04 12:00:00      NaN
2015-02-04 16:00:00     13.0
2015-02-04 20:00:00     13.0
2015-02-05 00:00:00     14.0
2015-02-05 04:00:00     19.0
2015-02-05 08:00:00     19.0
2015-02-05 12:00:00     19.0
2015-02-05 16:00:00     19.0
2015-02-05 20:00:00     19.0
Freq: 4H, Name: Units, dtype: float64
```

Let's practice!

Manipulating time series data

Sales data

```
In [1]: import pandas as pd

In [2]: sales = pd.read_csv('sales-feb-2015.csv',
   ...:                     parse_dates=['Date'])

In [3]: sales.head()
Out[3]:
                 Date         Company   Product  Units
0 2015-02-02 08:30:00           Hooli  Software      3
1 2015-02-02 21:00:00       Mediacore  Hardware      9
2 2015-02-03 14:00:00         Initech  Software     13
3 2015-02-04 15:30:00       Streeplex  Software     13
4 2015-02-04 22:00:00  Acme Coporation  Hardware     14
```

String methods

```
In [4]: sales['Company'].str.upper()
Out[4]:
0                HOOLI
1            MEDIACORE
2              INITECH
3            STREEPLEX
4      ACME COPORATION
5      ACME COPORATION
6                HOOLI
7      ACME COPORATION
8            STREEPLEX
9            MEDIACORE
10             INITECH
11               HOOLI
12               HOOLI
13           MEDIACORE
14           MEDIACORE
15           MEDIACORE
…
```

Substring matching

```
In [5]: sales['Product'].str.contains('ware')
Out[5]:
0      True
1      True
2      True
3      True
4      True
5      True
6     False
7      True
8     False
9      True
10     True
11     True
12     True
13     True
14    False
…
```

Boolean arithmetic

```
In [6]: True + False
Out[6]: 1

In [7]: True + True
Out[7]: 2

In [8]: False + False
Out[8]: 0
```

Boolean reduction

```
In [9]: sales['Product'].str.contains('ware').sum()
Out[9]: 14
```

Datetime methods

```
In [9]: sales['Date'].dt.hour
Out[9]:
0        8
1       21
2       14
3       15
4       22
5        2
6       22
7       23
8        9
9       13
10      20
11      23
12      12
13      11
14      16
…
```

Set timezone

```
In [10]: central = sales['Date'].dt.tz_localize('US/Central')

In [11]: central
Out[11]:
0     2015-02-02 08:30:00-06:00
1     2015-02-02 21:00:00-06:00
2     2015-02-03 14:00:00-06:00
3     2015-02-04 15:30:00-06:00
4     2015-02-04 22:00:00-06:00
5     2015-02-05 02:00:00-06:00
6     2015-02-05 22:00:00-06:00
7     2015-02-07 23:00:00-06:00
8     2015-02-09 09:00:00-06:00
9     2015-02-09 13:00:00-06:00
10    2015-02-11 20:00:00-06:00
11    2015-02-11 23:00:00-06:00
12    2015-02-16 12:00:00-06:00
…
Name: Date, dtype: datetime64[ns, US/Central]
```

Convert timezone

```
In [12]: central.dt.tz_convert('US/Eastern')
Out[12]:
0     2015-02-02 09:30:00-05:00
1     2015-02-02 22:00:00-05:00
2     2015-02-03 15:00:00-05:00
3     2015-02-04 16:30:00-05:00
4     2015-02-04 23:00:00-05:00
5     2015-02-05 03:00:00-05:00
6     2015-02-05 23:00:00-05:00
7     2015-02-08 00:00:00-05:00
8     2015-02-09 10:00:00-05:00
9     2015-02-09 14:00:00-05:00
10    2015-02-11 21:00:00-05:00
11    2015-02-12 00:00:00-05:00
12    2015-02-16 13:00:00-05:00
13    2015-02-19 12:00:00-05:00
14    2015-02-19 17:00:00-05:00
…
Name: Date, dtype: datetime64[ns, US/Eastern]
```

Method chaining

```
In [13]: sales['Date'].dt.tz_localize('US/Central').
    ...: dt.tz_convert('US/Eastern')
Out[13]:
0     2015-02-02 09:30:00-05:00
1     2015-02-02 22:00:00-05:00
2     2015-02-03 15:00:00-05:00
3     2015-02-04 16:30:00-05:00
4     2015-02-04 23:00:00-05:00
5     2015-02-05 03:00:00-05:00
6     2015-02-05 23:00:00-05:00
7     2015-02-08 00:00:00-05:00
8     2015-02-09 10:00:00-05:00
9     2015-02-09 14:00:00-05:00
10    2015-02-11 21:00:00-05:00
11    2015-02-12 00:00:00-05:00
12    2015-02-16 13:00:00-05:00
13    2015-02-19 12:00:00-05:00
14    2015-02-19 17:00:00-05:00
…
Name: Date, dtype: datetime64[ns, US/Eastern]
```

World Population

```
In [14]: population = pd.read_csv('world_population.csv',
    ...: parse_dates=True, index_col= 'Date')

In [15]: population
Out[15]:
              Population
Date
1960-12-31  2.087485e+10
1970-12-31  2.536513e+10
1980-12-31  3.057186e+10
1990-12-31  3.644928e+10
2000-12-31  4.228550e+10
2010-12-31  4.802217e+10
```

Upsample population

```
In [16]: population.resample('A').first()
Out[16]:
              Population
Date
1960-12-31  2.087485e+10
1961-12-31           NaN
1962-12-31           NaN
1963-12-31           NaN
1964-12-31           NaN
1965-12-31           NaN
1966-12-31           NaN
1967-12-31           NaN
1968-12-31           NaN
1969-12-31           NaN
1970-12-31  2.536513e+10
1971-12-31           NaN
1972-12-31           NaN
```

Interpolate missing data

```
In [17]: population.resample('A').first().interpolate('linear')
Out[17]:
              Population
Date
1960-12-31  2.087485e+10
1961-12-31  2.132388e+10
1962-12-31  2.177290e+10
1963-12-31  2.222193e+10
1964-12-31  2.267096e+10
1965-12-31  2.311999e+10
1966-12-31  2.356902e+10
1967-12-31  2.401805e+10
1968-12-31  2.446707e+10
1969-12-31  2.491610e+10
1970-12-31  2.536513e+10
1971-12-31  2.588580e+10
1972-12-31  2.640648e+10
```

Let's practice!

Time series visualization

Topics

- Line types
- Plot types
- Subplots

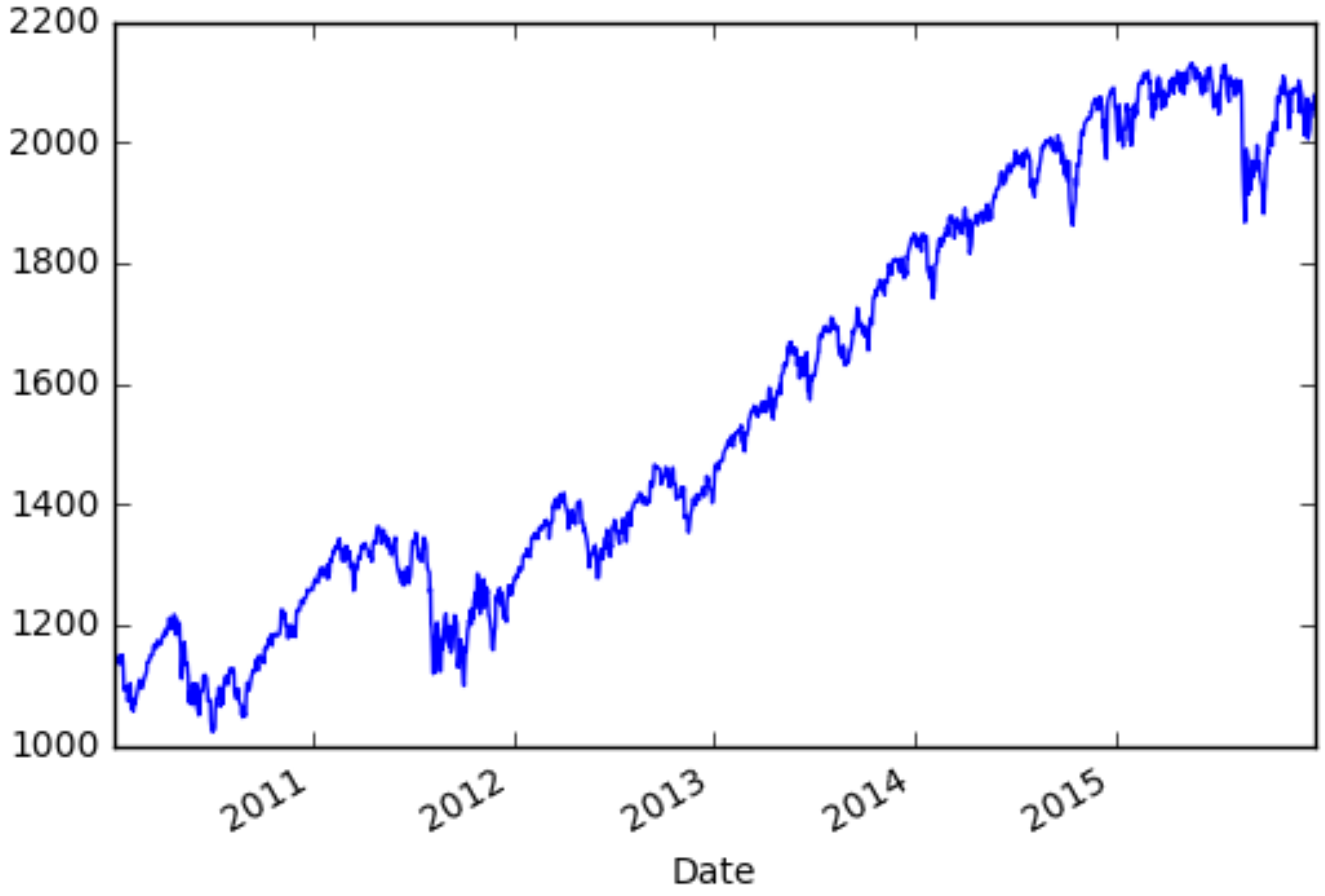
S&P 500 Data

```
In [1]: import pandas as pd

In [2]: import matplotlib.pyplot as plt

In [3]: sp500 = pd.read_csv('sp500.csv', parse_dates=True,
   ...:                     index_col= 'Date')

In [4]: sp500.head()
Out[4]:
                   Open         High          Low        Close      Volume    Adj Close
Date
2010-01-04  1116.560059  1133.869995  1116.560059  1132.989990  3991400000  1132.989990
2010-01-05  1132.660034  1136.630005  1129.660034  1136.520020  2491020000  1136.520020
2010-01-06  1135.709961  1139.189941  1133.949951  1137.140015  4972660000  1137.140015
2010-01-07  1136.270020  1142.459961  1131.319946  1141.689941  5270680000  1141.689941
2010-01-08  1140.520020  1145.390015  1136.219971  1144.979980  4389590000  1144.979980
```

Pandas plot

```
In [5]: sp500['Close'].plot()

In [6]: plt.show()
```

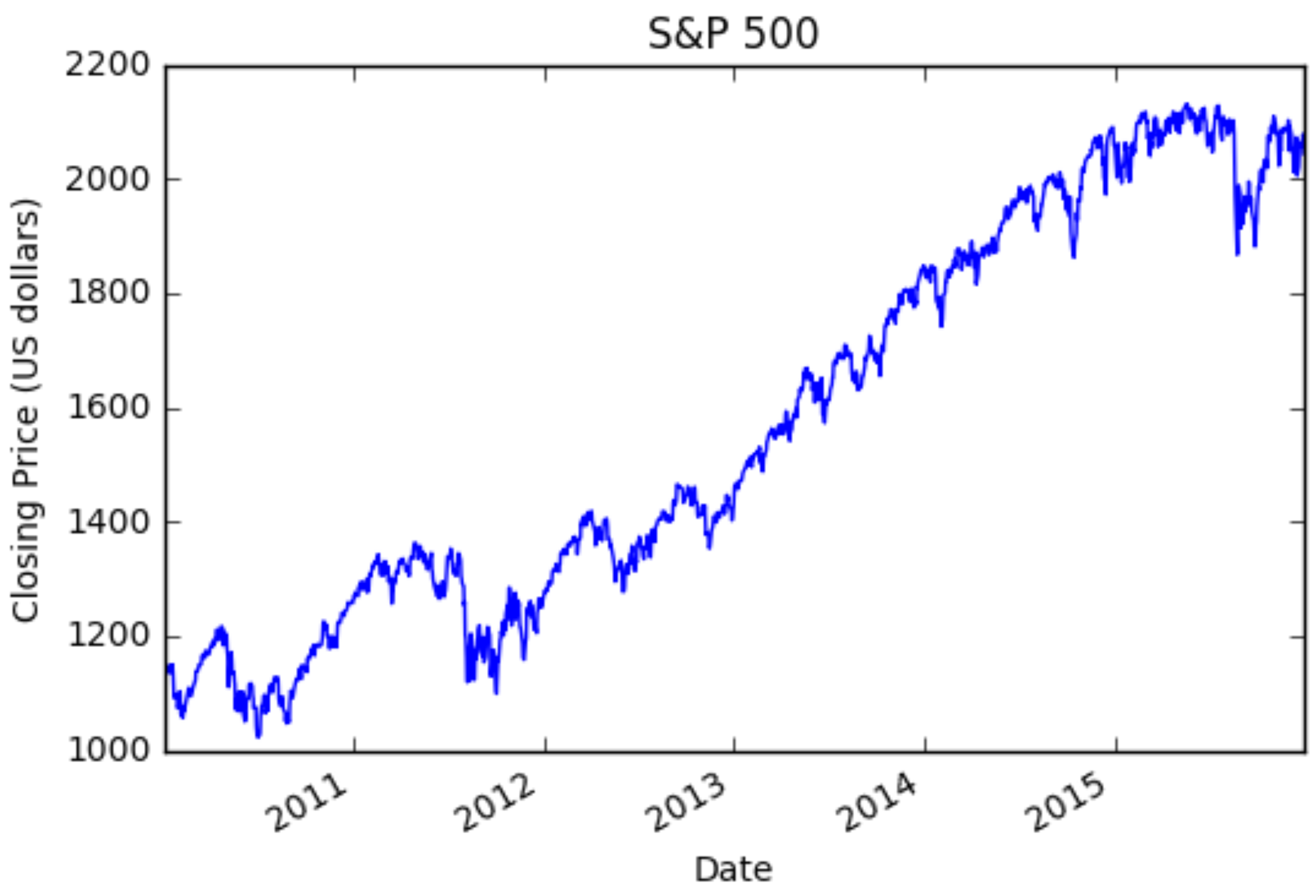
Default plot



Labels and title

```
In [7]: sp500['Close'].plot(title='S&P 500')

In [8]: plt.ylabel('Closing Price (US Dollars)')

In [9]: plt.show()
```

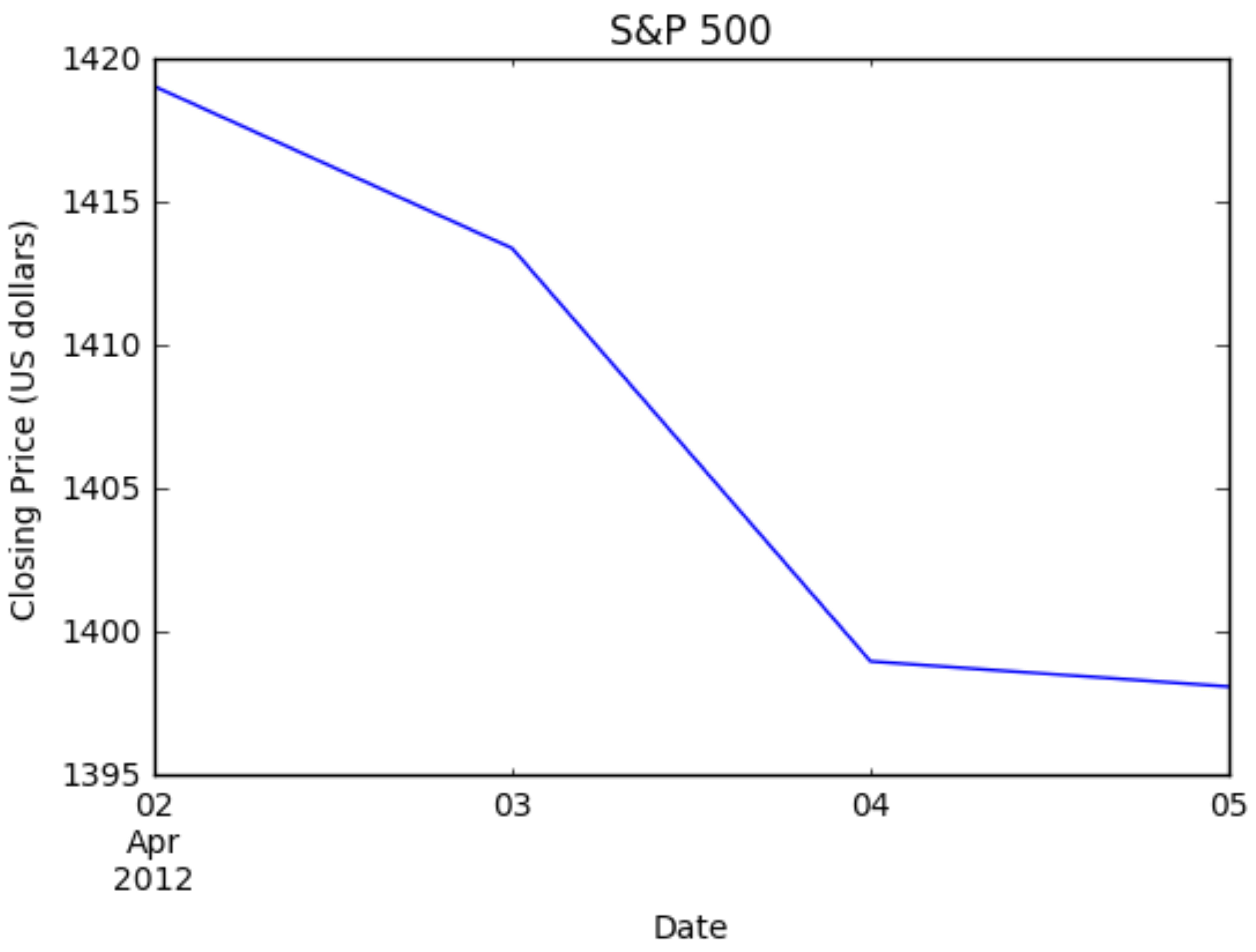
Labels and title



One week

```
In [10]: sp500.loc['2012-4-1':'2012-4-7', 'Close'].plot(title='S&P
    ...: 500')

In [11]: plt.ylabel('Closing Price (US Dollars)')

In [12]: plt.show()
```

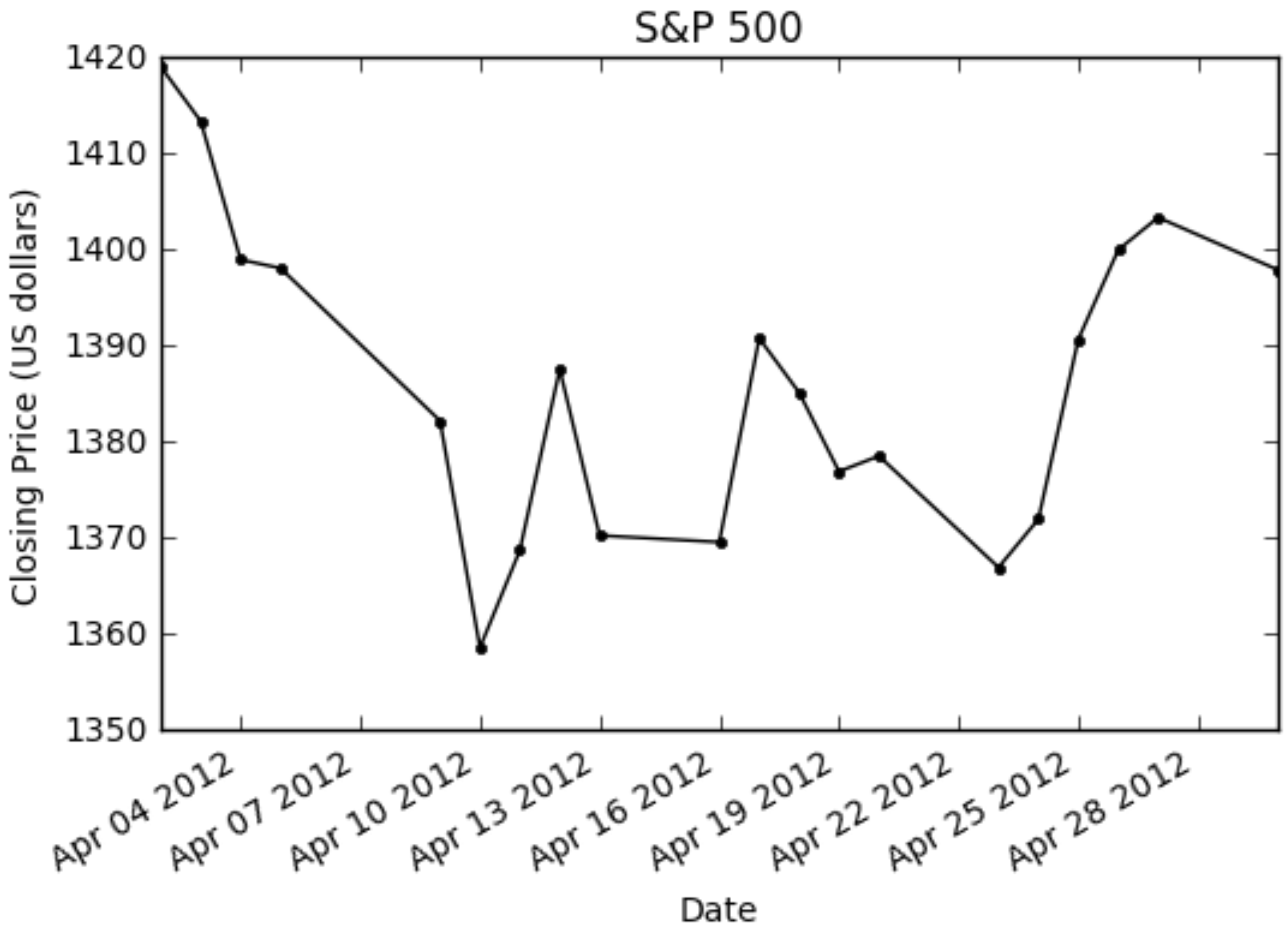
One week


S&P 500
1420
1415
1410
1405
1400
1395
Closing Price (US dollars)
02
Apr
2012
03
04
05
Date

Plot styles

```
In [13]: sp500.loc['2012-4', 'Close'].plot(style='k.-',
    ...:                                   title='S&P500')

In [14]: plt.ylabel('Closing Price (US Dollars)')

In [15]: plt.show()
```

One week


S&P 500
Closing Price (US dollars)
1420
1410
1400
1390
1380
1370
1360
1350
Apr 04 2012
Apr 07 2012
Apr 10 2012
Apr 13 2012
Apr 16 2012
Apr 19 2012
Apr 22 2012
Apr 25 2012
Apr 28 2012
Date

More plot styles

- Style format string
    - color (k: black)
    - marker (. : dot)
    - line type (-: solid)

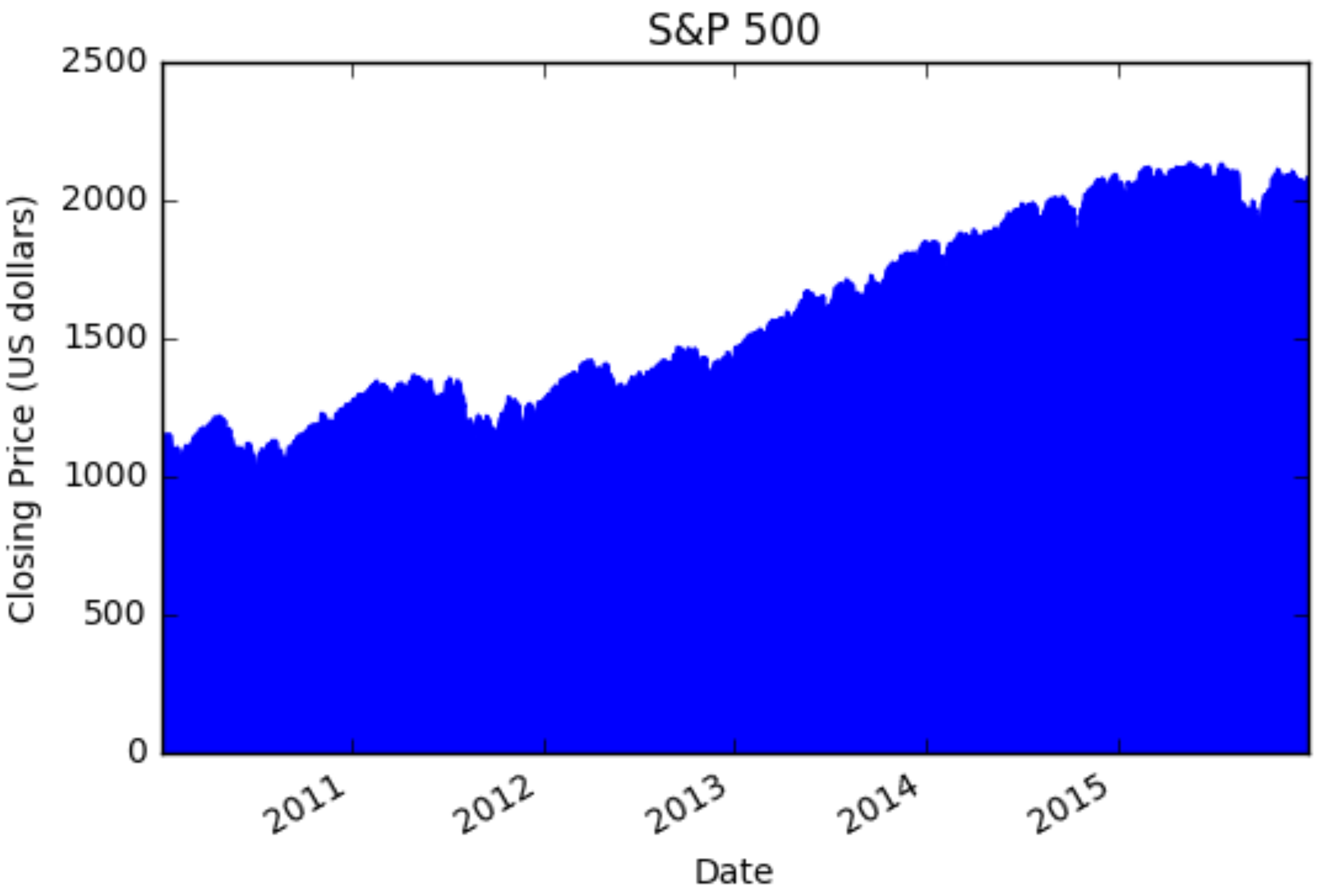
More plot styles

Color	Marker	Line
b: blue	o: circle	: dotted
g: green	*: star	–: dashed
r: red	s: square	
c: cyan	+: plus	

Area plot

```
In [16]: sp500['Close'].plot(kind='area', title='S&P 500')

In [17]: plt.ylabel('Closing Price (US Dollars)')

In [18]: plt.show()
```

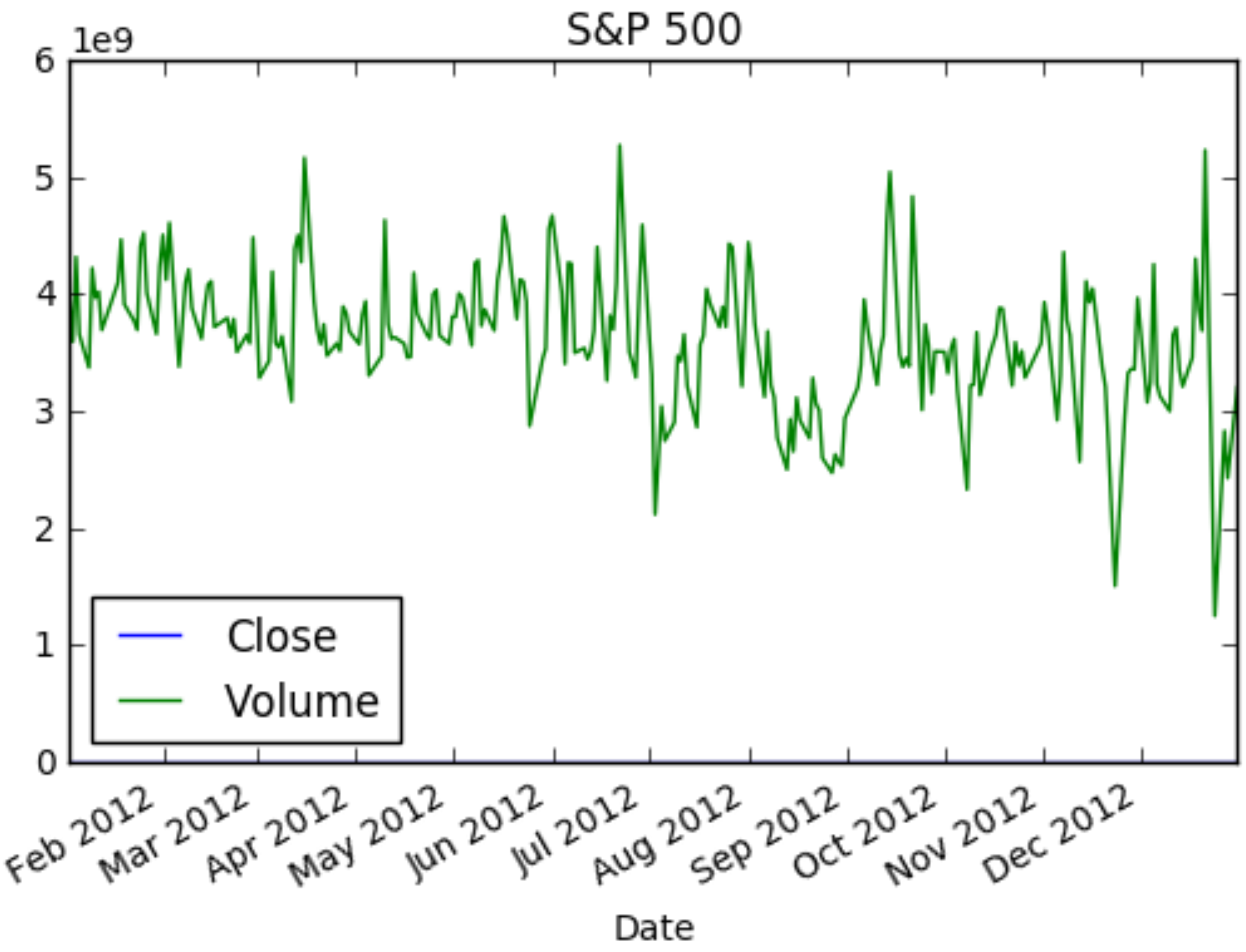
Area plot


S&P 500
2500
2000
1500
1000
500
0
Closing Price (US dollars)
2011
2012
2013
2014
2015
Date

Multiple columns

```
In [19]: sp500.loc['2012', ['Close','Volume']].plot(title='S&P
    ...: 500')

In [20]: plt.show()
```

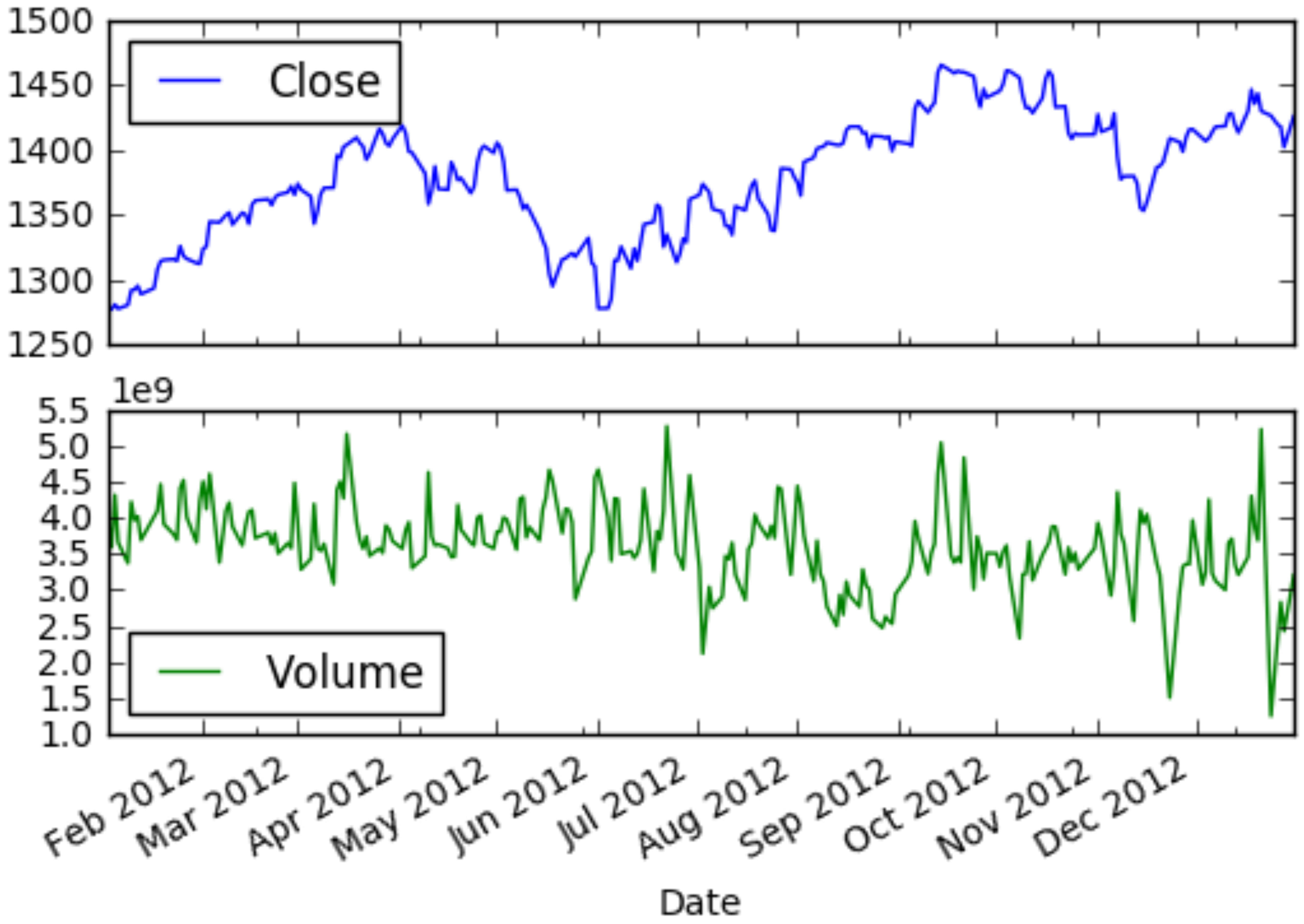
Multiple columns



Subplots

```
In [21]: sp500.loc['2012', ['Close','Volume']].plot(subplots=True)

In [22]: plt.show()
```

Subplots


1500
1450
1400
1350
1300
1250
Close
1e9
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Volume
Feb 2012
Mar 2012
Apr 2012
May 2012
Jun 2012
Jul 2012
Aug 2012
Sep 2012
Oct 2012
Nov 2012
Dec 2012
Date

Let's practice!