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TASKS:-

1. Download the csv file for time series data about Covid-19 cases in India.
2. Pre-process the data to check about any missing data.
3. Plot the time series to visualise it.
4. Identify the trend, seasonality and remainder parts of the time series.
5. Identify the SARIMAX parameters
6. Forecast the time series for next 100 days.
7. Plot your forecasted data along with the original data.

In [1]:

```
import warnings
import itertools
import numpy as np
import matplotlib.pyplot as plt
warnings.filterwarnings("ignore")
plt.style.use('fivethirtyeight')
import pandas as pd
import statsmodels.api as sm
import matplotlib
matplotlib.rcParams['axes.labelsize'] = 14
matplotlib.rcParams['xtick.labelsize'] = 12
matplotlib.rcParams['ytick.labelsize'] = 12
matplotlib.rcParams['text.color'] = 'k'
```

In [2]:

```
kp = pd.read_csv(r'C:\Users\Admin\Downloads\case_time_series.csv')
```

In [3]:

```
#print first five row
kp.head()
```

Out[3]:

	Date	Daily Confirmed	Total Confirmed	Daily Recovered	Total Recovered	Daily Deceased	Total Deceased
0	30-Jan	1	1	0	0	0	0
1	31-Jan	0	1	0	0	0	0
2	01-Feb	0	1	0	0	0	0
3	02-Feb	1	2	0	0	0	0
4	03-Feb	1	3	0	0	0	0

In [4]:
```
kp['Date'] = pd.to_datetime(kp['Date']+'-20', format='%d-%b-%y')
kp
```

Out[4]:

	Date	Daily Confirmed	Total Confirmed	Daily Recovered	Total Recovered	Daily Deceased	Total Deceased
0	2020-01-30	1	1	0	0	0	0
1	2020-01-31	0	1	0	0	0	0
2	2020-02-01	0	1	0	0	0	0
3	2020-02-02	1	2	0	0	0	0
4	2020-02-03	1	3	0	0	0	0
...	...	...	...	...	...	...	...
88	2020-04-27	1568	29458	580	7103	58	939
89	2020-04-28	1902	31360	636	7739	69	1008
90	2020-04-29	1705	33065	690	8429	71	1079
91	2020-04-30	1801	34866	630	9059	75	1154
92	2020-05-01	2391	37257	962	10021	69	1223

93 rows × 7 columns

In [5]:
```
#print random five row
kp.sample(5)
```

Out[5]:

	Date	Daily Confirmed	Total Confirmed	Daily Recovered	Total Recovered	Daily Deceased	Total Deceased
79	2020-04-18	1371	15725	426	2466	35	522
62	2020-04-01	424	2059	19	169	6	53
73	2020-04-12	758	9211	114	1086	42	332
33	2020-03-03	1	6	0	3	0	0
64	2020-04-03	560	3105	39	230	14	83

In [6]:

```
#full information
kp.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 93 entries, 0 to 92
Data columns (total 7 columns):
 #   Column           Non-Null Count  Dtype         
---  ------           --------------  -----         
 0   Date             93 non-null     datetime64[ns]
 1   Daily Confirmed  93 non-null     int64         
 2   Total Confirmed  93 non-null     int64         
 3   Daily Recovered  93 non-null     int64         
 4   Total Recovered  93 non-null     int64         
 5   Daily Deceased   93 non-null     int64         
 6   Total Deceased   93 non-null     int64         
dtypes: datetime64[ns](1), int64(6)
memory usage: 5.2 KB
```

In [7]:

```
#statistical information
kp[['Date']].describe()
```

Out[7]:

	Date
count	93
unique	93
top	2020-03-13 00:00:00
freq	1
first	2020-01-30 00:00:00
last	2020-05-01 00:00:00

In [8]:

```
# unstacking the data
kp.unstack().head()
```

Out[8]:

```
Date  0    2020-01-30 00:00:00
      1    2020-01-31 00:00:00
      2    2020-02-01 00:00:00
      3    2020-02-02 00:00:00
      4    2020-02-03 00:00:00
dtype: object
```

In [9]:

```
kp.unstack().head().values
```

Out[9]:

```
array([Timestamp('2020-01-30 00:00:00'), Timestamp('2020-01-31 00:00:00'),
       Timestamp('2020-02-01 00:00:00'), Timestamp('2020-02-02 00:00:00'),
       Timestamp('2020-02-03 00:00:00')], dtype=object)
```

In [10]:

```
kp['Date'].min(), kp['Date'].max()
```

Out[10]:

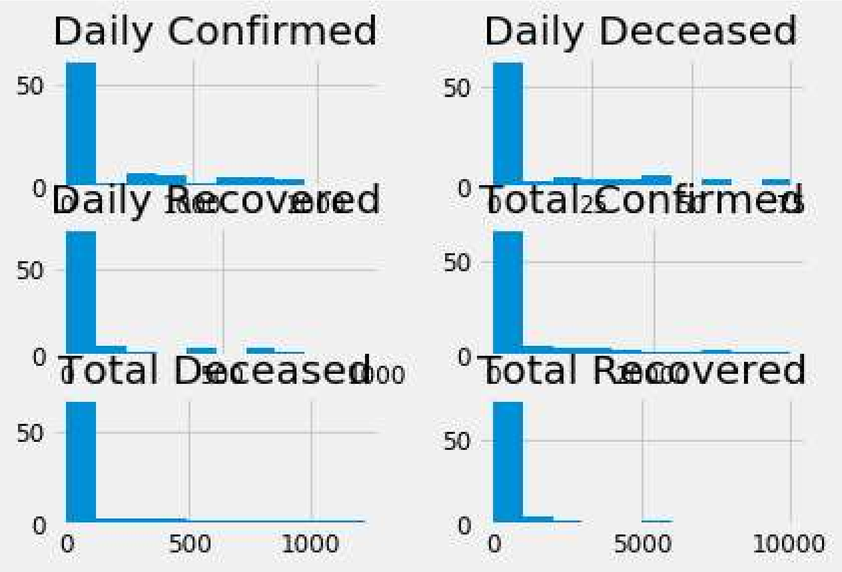
```
(Timestamp('2020-01-30 00:00:00'), Timestamp('2020-05-01 00:00:00'))
```

In [11]:

```
kp.hist()
```

Out[11]:

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x000001987D5031F0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001987F622D30
>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001987F65A5B0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001987F682E20
>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001987F6B56A0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001987F6E1EE0
>]],
      dtype=object)
```



In [12]:

```
kp.columns
```

Out[12]:

```
Index(['Date', 'Daily Confirmed', 'Total Confirmed', 'Daily Recovered',
       'Total Recovered', 'Daily Deceased', 'Total Deceased'],
      dtype='object')
```

In [13]:

```
kp.index
```

Out[13]:

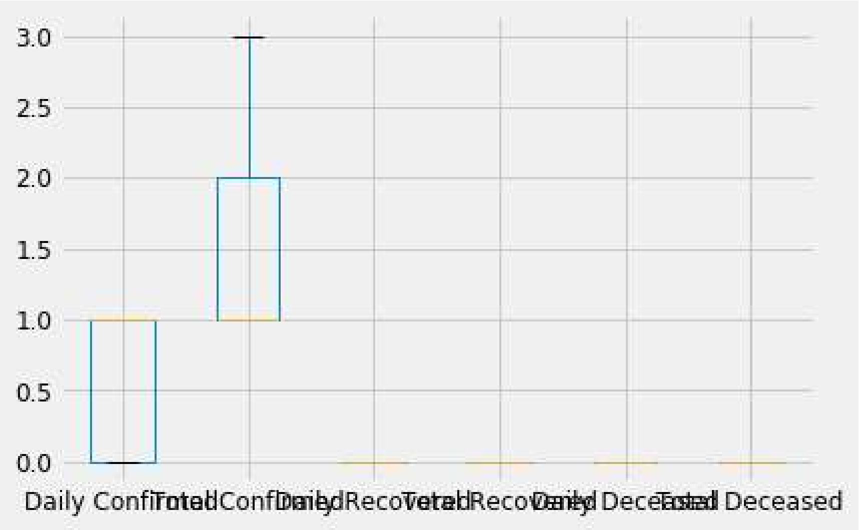
```
RangeIndex(start=0, stop=93, step=1)
```

In [14]:

```
kp.head().boxplot()
```

Out[14]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1987f7d9a30>
```



In [15]:

```
kp.isnull().sum()
```

Out[15]:

```
Date               0
Daily Confirmed    0
Total Confirmed    0
Daily Recovered    0
Total Recovered    0
Daily Deceased     0
Total Deceased     0
dtype: int64
```

In [16]:

```
kp= kp.sort_values('Date')
kp.isnull().sum()
```

Out[16]:

```
Date               0
Daily Confirmed    0
Total Confirmed    0
Daily Recovered    0
Total Recovered    0
Daily Deceased     0
Total Deceased     0
dtype: int64
```

In [17]:

```
len(kp)
```

Out[17]:

```
93
```

In [18]:

```
kp = kp.groupby('Date')['Daily Confirmed'].sum().reset_index()
```

In [19]:

```
kp = kp.set_index('Date')
kp.index = pd.to_datetime(kp.index)
kp.index
```

Out[19]:

```
DatetimeIndex(['2020-01-30', '2020-01-31', '2020-02-01', '2020-02-02',
               '2020-02-03', '2020-02-04', '2020-02-05', '2020-02-06',
               '2020-02-07', '2020-02-08', '2020-02-09', '2020-02-10',
               '2020-02-11', '2020-02-12', '2020-02-13', '2020-02-14',
               '2020-02-15', '2020-02-16', '2020-02-17', '2020-02-18',
               '2020-02-19', '2020-02-20', '2020-02-21', '2020-02-22',
               '2020-02-23', '2020-02-24', '2020-02-25', '2020-02-26',
               '2020-02-27', '2020-02-28', '2020-02-29', '2020-03-01',
               '2020-03-02', '2020-03-03', '2020-03-04', '2020-03-05',
               '2020-03-06', '2020-03-07', '2020-03-08', '2020-03-09',
               '2020-03-10', '2020-03-11', '2020-03-12', '2020-03-13',
               '2020-03-14', '2020-03-15', '2020-03-16', '2020-03-17',
               '2020-03-18', '2020-03-19', '2020-03-20', '2020-03-21',
               '2020-03-22', '2020-03-23', '2020-03-24', '2020-03-25',
               '2020-03-26', '2020-03-27', '2020-03-28', '2020-03-29',
               '2020-03-30', '2020-03-31', '2020-04-01', '2020-04-02',
               '2020-04-03', '2020-04-04', '2020-04-05', '2020-04-06',
               '2020-04-07', '2020-04-08', '2020-04-09', '2020-04-10',
               '2020-04-11', '2020-04-12', '2020-04-13', '2020-04-14',
               '2020-04-15', '2020-04-16', '2020-04-17', '2020-04-18',
               '2020-04-19', '2020-04-20', '2020-04-21', '2020-04-22',
               '2020-04-23', '2020-04-24', '2020-04-25', '2020-04-26',
               '2020-04-27', '2020-04-28', '2020-04-29', '2020-04-30',
               '2020-05-01'],
              dtype='datetime64[ns]', name='Date', freq=None)
```

In [20]:

```
y = kp['Daily Confirmed'].resample('W').mean()
```

In [21]:

```
y.index
```

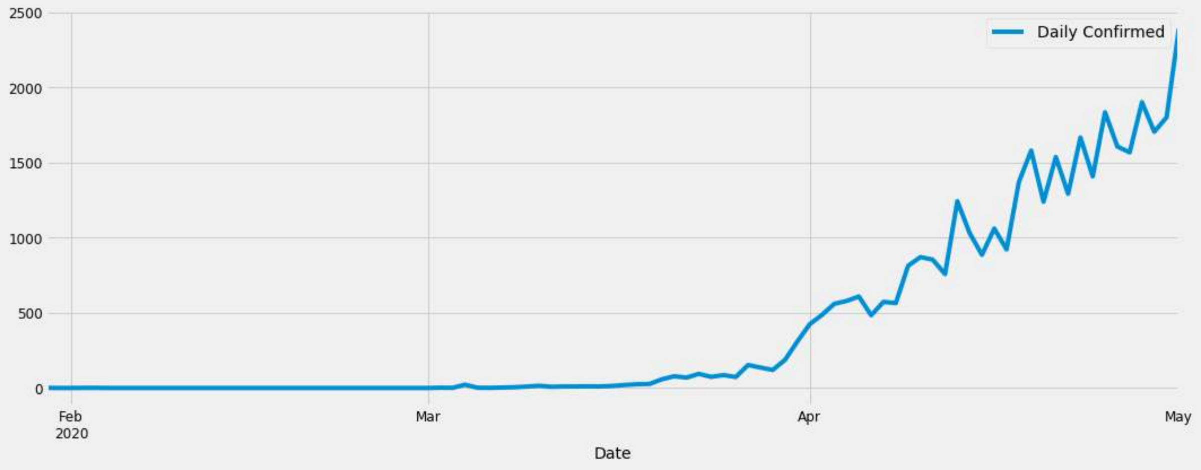
Out[21]:

```
DatetimeIndex(['2020-02-02', '2020-02-09', '2020-02-16', '2020-02-23',
               '2020-03-01', '2020-03-08', '2020-03-15', '2020-03-22',
               '2020-03-29', '2020-04-05', '2020-04-12', '2020-04-19',
               '2020-04-26', '2020-05-03'],
              dtype='datetime64[ns]', name='Date', freq='W-SUN')
```

In [22]:
```
y['2020':]
```

Out[22]:
```
Date
2020-02-02       0.500000
2020-02-09       0.142857
2020-02-16       0.000000
2020-02-23       0.000000
2020-03-01       0.000000
2020-03-08       5.142857
2020-03-15      10.428571
2020-03-22      41.571429
2020-03-29     105.142857
2020-04-05     450.571429
2020-04-12     702.571429
2020-04-19    1156.285714
2020-04-26    1512.142857
2020-05-03    1873.400000
Freq: W-SUN, Name: Daily Confirmed, dtype: float64
```

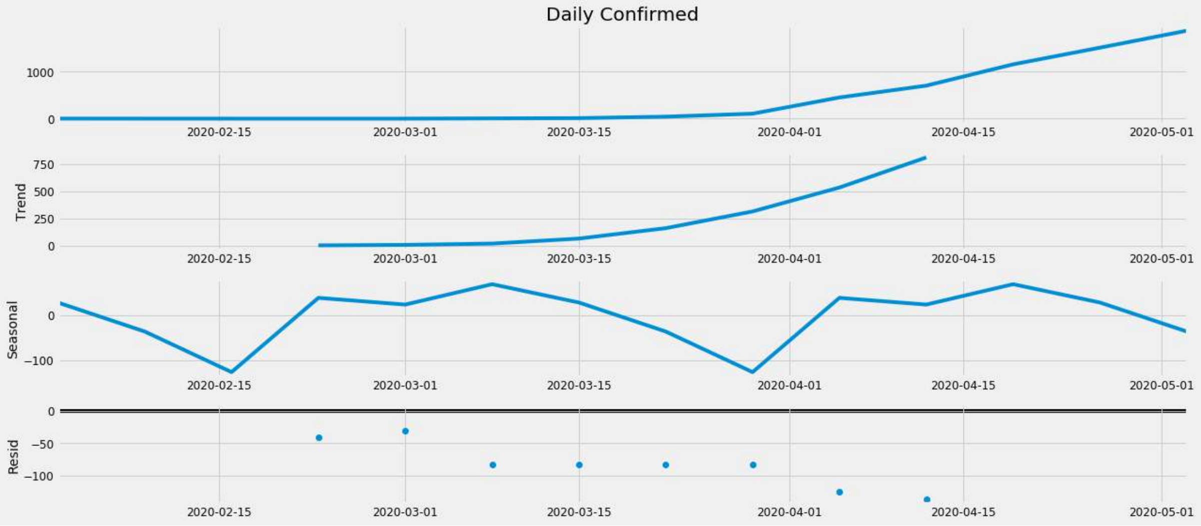
In [23]:
```
kp.plot(figsize=(16, 6))
plt.show()
```



In [24]:
```
y.fillna(method='ffill',inplace=True) #Handling the missing value
```

In [25]:

```
from pylab import rcParams
rcParams['figure.figsize'] = 18, 8
decomposition = sm.tsa.seasonal_decompose(y,freq=6,model='additive')
fig = decomposition.plot()
plt.show()  #x must have 2 complete cycles requires 104 observations. x only has 14 observation(s):-freq=7
```



In [26]:

```
p = d = q = range(0, 2)
pdq = list(itertools.product(p, d, q))
seasonal_pdq = [(x[0], x[1], x[2], 12) for x in list(itertools.product(p, d, q))]
print('Examples of parameter combinations for Seasonal ARIMA...')
print('SARIMAX: {} x {}'.format(pdq[1], seasonal_pdq[1]))
print('SARIMAX: {} x {}'.format(pdq[1], seasonal_pdq[2]))
print('SARIMAX: {} x {}'.format(pdq[2], seasonal_pdq[3]))
print('SARIMAX: {} x {}'.format(pdq[2], seasonal_pdq[4]))
```

```
Examples of parameter combinations for Seasonal ARIMA...
SARIMAX: (0, 0, 1) x (0, 0, 1, 12)
SARIMAX: (0, 0, 1) x (0, 1, 0, 12)
SARIMAX: (0, 1, 0) x (0, 1, 1, 12)
SARIMAX: (0, 1, 0) x (1, 0, 0, 12)
```

In [27]:

```
for param in pdq:
    for param_seasonal in seasonal_pdq:
        try:
            mod = sm.tsa.statespace.SARIMAX(y,
                                            order=param,
                                            seasonal_order=param_seasonal,
                                            enforce_stationarity=False,
                                            enforce_invertibility=False)
            results = mod.fit()
            print('ARIMA{}x{}12 - AIC:{}'.format(param, param_seasonal, result
s.aic))
        except:
            continue
```

```
ARIMA(0, 0, 0)x(0, 0, 0, 12)12 - AIC:211.92452135174656
ARIMA(0, 0, 0)x(0, 0, 1, 12)12 - AIC:21.90873976828057
ARIMA(0, 0, 0)x(0, 1, 0, 12)12 - AIC:19.91815079494886
ARIMA(0, 0, 0)x(0, 1, 1, 12)12 - AIC:4.0
ARIMA(0, 0, 0)x(1, 0, 0, 12)12 - AIC:37.22588383766065
ARIMA(0, 0, 0)x(1, 0, 1, 12)12 - AIC:23.90751082102666
ARIMA(0, 0, 0)x(1, 1, 0, 12)12 - AIC:4.0
ARIMA(0, 0, 0)x(1, 1, 1, 12)12 - AIC:6.0
ARIMA(0, 0, 1)x(0, 0, 0, 12)12 - AIC:188.30999133092075

c:\users\admin\appdata\local\programs\python\python38\lib\site-packages\stats
models\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "

ARIMA(0, 0, 1)x(0, 0, 1, 12)12 - AIC:6.0
ARIMA(0, 0, 1)x(0, 1, 0, 12)12 - AIC:4.0
ARIMA(0, 0, 1)x(0, 1, 1, 12)12 - AIC:6.0
ARIMA(0, 0, 1)x(1, 0, 0, 12)12 - AIC:39.28209806737616
ARIMA(0, 0, 1)x(1, 0, 1, 12)12 - AIC:8.0
ARIMA(0, 0, 1)x(1, 1, 0, 12)12 - AIC:6.0

c:\users\admin\appdata\local\programs\python\python38\lib\site-packages\stats
models\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "

ARIMA(0, 0, 1)x(1, 1, 1, 12)12 - AIC:8.0
ARIMA(0, 1, 0)x(0, 0, 0, 12)12 - AIC:166.86879376113723
ARIMA(0, 1, 0)x(0, 0, 1, 12)12 - AIC:4.0
ARIMA(0, 1, 0)x(0, 1, 0, 12)12 - AIC:2.0
ARIMA(0, 1, 0)x(1, 0, 0, 12)12 - AIC:5.285428631112563
ARIMA(0, 1, 0)x(1, 0, 1, 12)12 - AIC:6.0
ARIMA(0, 1, 1)x(0, 0, 0, 12)12 - AIC:150.30054865437197
ARIMA(0, 1, 1)x(0, 0, 1, 12)12 - AIC:6.0

c:\users\admin\appdata\local\programs\python\python38\lib\site-packages\stats
models\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "

ARIMA(0, 1, 1)x(1, 0, 0, 12)12 - AIC:-1.2891822924210592
ARIMA(0, 1, 1)x(1, 0, 1, 12)12 - AIC:8.0
ARIMA(1, 0, 0)x(0, 0, 0, 12)12 - AIC:164.81248757301356

c:\users\admin\appdata\local\programs\python\python38\lib\site-packages\stats
models\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
c:\users\admin\appdata\local\programs\python\python38\lib\site-packages\stats
models\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "

ARIMA(1, 0, 0)x(0, 0, 1, 12)12 - AIC:-1.8134136036754276
ARIMA(1, 0, 0)x(0, 1, 0, 12)12 - AIC:-3.0160183369146836
ARIMA(1, 0, 0)x(0, 1, 1, 12)12 - AIC:6.0
```

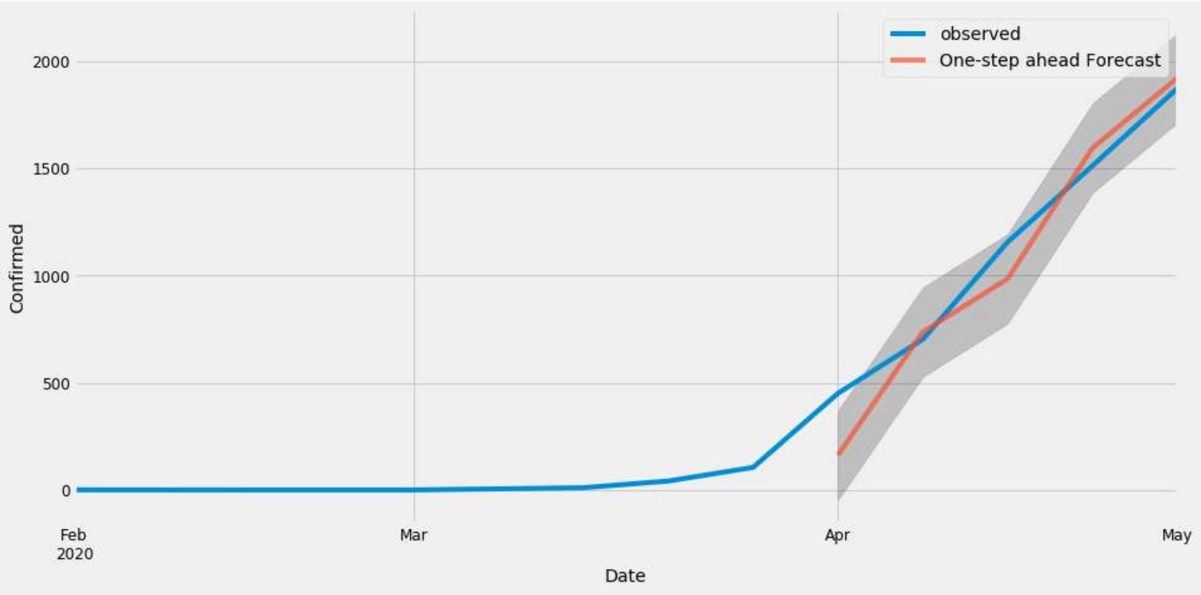
```
c:\users\admin\appdata\local\programs\python\python38\lib\site-packages\stats
models\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "

ARIMA(1, 0, 0)x(1, 0, 0, 12)12 - AIC:10.83766813551634
ARIMA(1, 0, 0)x(1, 0, 1, 12)12 - AIC:1.6920154333967572
ARIMA(1, 0, 0)x(1, 1, 0, 12)12 - AIC:6.0
ARIMA(1, 0, 0)x(1, 1, 1, 12)12 - AIC:8.0
ARIMA(1, 0, 1)x(0, 0, 0, 12)12 - AIC:153.97658215516896
ARIMA(1, 0, 1)x(0, 0, 1, 12)12 - AIC:8.0
ARIMA(1, 0, 1)x(0, 1, 0, 12)12 - AIC:6.0
ARIMA(1, 0, 1)x(0, 1, 1, 12)12 - AIC:8.0

c:\users\admin\appdata\local\programs\python\python38\lib\site-packages\stats
models\base\model.py:566: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "

ARIMA(1, 0, 1)x(1, 0, 0, 12)12 - AIC:15.678086400549422
ARIMA(1, 0, 1)x(1, 0, 1, 12)12 - AIC:10.0
ARIMA(1, 0, 1)x(1, 1, 0, 12)12 - AIC:8.0
ARIMA(1, 0, 1)x(1, 1, 1, 12)12 - AIC:10.0
ARIMA(1, 1, 0)x(0, 0, 0, 12)12 - AIC:150.44277957771686
ARIMA(1, 1, 0)x(0, 0, 1, 12)12 - AIC:6.0
ARIMA(1, 1, 0)x(1, 0, 0, 12)12 - AIC:6.0
ARIMA(1, 1, 0)x(1, 0, 1, 12)12 - AIC:8.0
ARIMA(1, 1, 1)x(0, 0, 0, 12)12 - AIC:139.92266006794583
ARIMA(1, 1, 1)x(0, 0, 1, 12)12 - AIC:8.0
ARIMA(1, 1, 1)x(1, 0, 0, 12)12 - AIC:8.0
ARIMA(1, 1, 1)x(1, 0, 1, 12)12 - AIC:10.0
```

In [28]:

```
mod = sm.tsa.statespace.SARIMAX(y,
                                order=(1, 1, 1),
                                seasonal_order=(0, 0, 0, 12),
                                enforce_stationarity=False,
                                enforce_invertibility=False)
results = mod.fit()
```

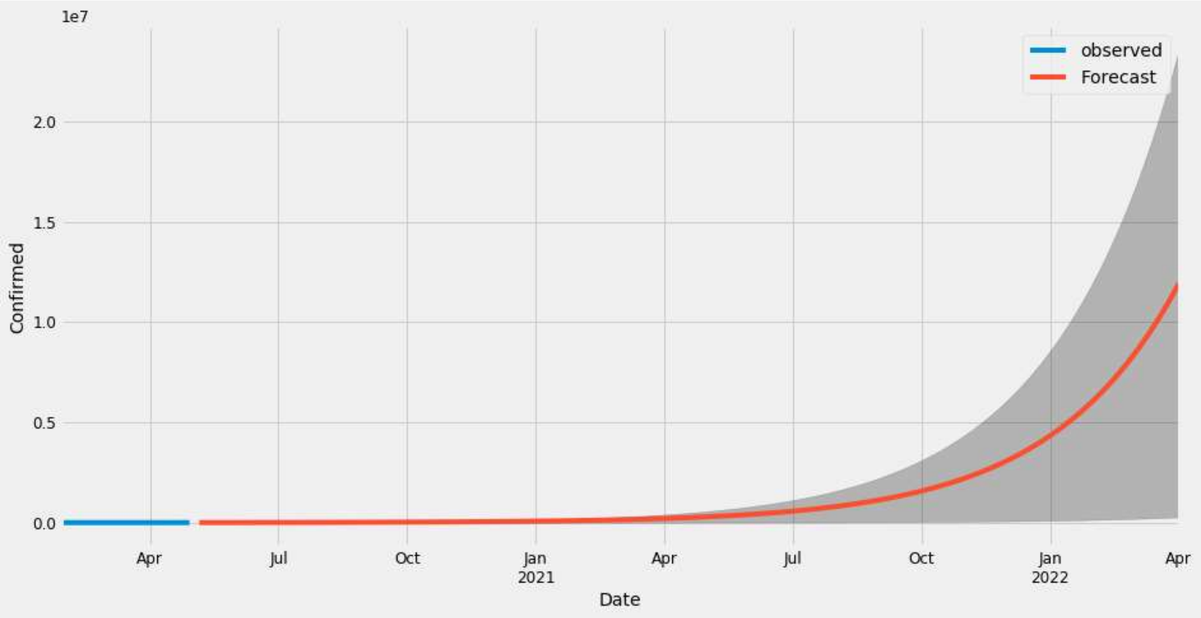
In [29]:

```
pred = results.get_prediction(start=pd.to_datetime('2020-04-05'), dynamic=False)
pred_ci = pred.conf_int()
ax = y['2020':].plot(label='observed')
pred.predicted_mean.plot(ax=ax, label='One-step ahead Forecast', alpha=.7, figsize=(14, 7))
ax.fill_between(pred_ci.index,
                pred_ci.iloc[:, 0],
                pred_ci.iloc[:, 1], color='k', alpha=.2)
ax.set_xlabel('Date')
ax.set_ylabel('Confirmed')
plt.legend()
plt.show()
```



In [30]:

```
import matplotlib.pyplot as plt
pred_uc = results.get_forecast(steps=100)
pred_ci = pred_uc.conf_int()
ax = y.plot(label='observed', figsize=(14, 7))
pred_uc.predicted_mean.plot(ax=ax, label='Forecast')
ax.fill_between(pred_ci.index,
                pred_ci.iloc[:, 0],
                pred_ci.iloc[:, 1], color='k', alpha=.25)
ax.set_xlabel('Date')
ax.set_ylabel('Confirmed')
plt.legend()
plt.show()
```



THANK YOU