In [1]:
```python
# To use PCA Algorithm for dimensionality reduction. You have a dataset that includ

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix
import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```python
data = pd.read_csv("wine.csv")
data.head()
```

Out[2]:

| | Alcohol | Malic_Acid | Ash | Ash_Alcanity | Magnesium | Total_Phenols | Flavanoids | Nonflav |
|---|---|---|---|---|---|---|---|---|
| **0** | 14.23 | 1.71 | 2.43 | 15.6 | 127 | 2.80 | 3.06 | |
| **1** | 13.20 | 1.78 | 2.14 | 11.2 | 100 | 2.65 | 2.76 | |
| **2** | 13.16 | 2.36 | 2.67 | 18.6 | 101 | 2.80 | 3.24 | |
| **3** | 14.37 | 1.95 | 2.50 | 16.8 | 113 | 3.85 | 3.49 | |
| **4** | 13.24 | 2.59 | 2.87 | 21.0 | 118 | 2.80 | 2.69 | |

In [3]:
```python
data.shape
```

Out[3]:
```
(178, 14)
```

In [4]:
```python
data.describe()
```

Out[4]:

| | Alcohol | Malic_Acid | Ash | Ash_Alcanity | Magnesium | Total_Phenols | Flavar |
|---|---|---|---|---|---|---|---|
| **count** | 178.000000 | 178.000000 | 178.000000 | 178.000000 | 178.000000 | 178.000000 | 178.0C |
| **mean** | 13.000618 | 2.336348 | 2.366517 | 19.494944 | 99.741573 | 2.295112 | 2.02 |
| **std** | 0.811827 | 1.117146 | 0.274344 | 3.339564 | 14.282484 | 0.625851 | 0.9S |
| **min** | 11.030000 | 0.740000 | 1.360000 | 10.600000 | 70.000000 | 0.980000 | 0.34 |
| **25%** | 12.362500 | 1.602500 | 2.210000 | 17.200000 | 88.000000 | 1.742500 | 1.2C |
| **50%** | 13.050000 | 1.865000 | 2.360000 | 19.500000 | 98.000000 | 2.355000 | 2.13 |
| **75%** | 13.677500 | 3.082500 | 2.557500 | 21.500000 | 107.000000 | 2.800000 | 2.87 |
| **max** | 14.830000 | 5.800000 | 3.230000 | 30.000000 | 162.000000 | 3.880000 | 5.08 |

In [5]:
```python
data.isnull().sum()
```

Out[5]:
```
Alcohol                 0
Malic_Acid              0
Ash                     0
Ash_Alcanity            0
Magnesium               0
Total_Phenols           0
Flavanoids              0
Nonflavanoid_Phenols    0
Proanthocyanins         0
Color_Intensity         0
Hue                     0
OD280                   0
Proline                 0
Customer_Segment        0
dtype: int64
```

In [6]:
```python
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 178 entries, 0 to 177
Data columns (total 14 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   Alcohol               178 non-null    float64
 1   Malic_Acid            178 non-null    float64
 2   Ash                   178 non-null    float64
 3   Ash_Alcanity          178 non-null    float64
 4   Magnesium             178 non-null    int64  
 5   Total_Phenols         178 non-null    float64
 6   Flavanoids            178 non-null    float64
 7   Nonflavanoid_Phenols  178 non-null    float64
 8   Proanthocyanins       178 non-null    float64
 9   Color_Intensity       178 non-null    float64
 10  Hue                   178 non-null    float64
 11  OD280                 178 non-null    float64
 12  Proline               178 non-null    int64  
 13  Customer_Segment      178 non-null    int64  
dtypes: float64(11), int64(3)
memory usage: 19.6 KB
```

In [7]:
```python
print(data.columns)
```

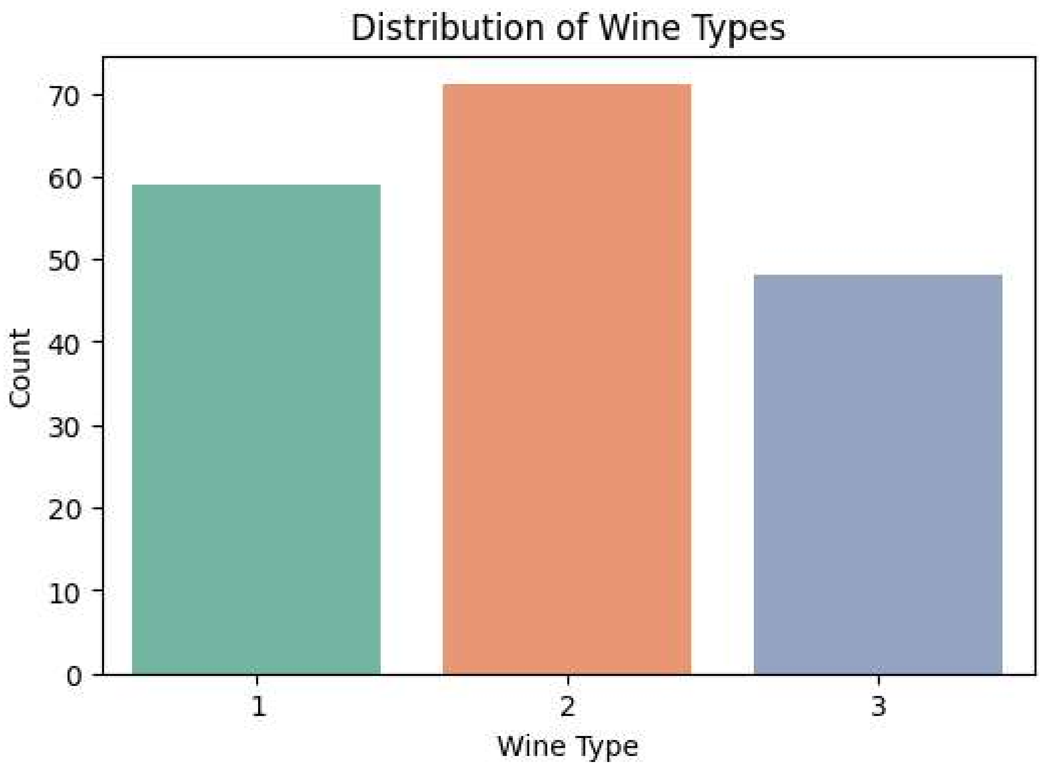
```
Index(['Alcohol', 'Malic_Acid', 'Ash', 'Ash_Alcanity', 'Magnesium',
       'Total_Phenols', 'Flavanoids', 'Nonflavanoid_Phenols',
       'Proanthocyanins', 'Color_Intensity', 'Hue', 'OD280', 'Proline',
       'Customer_Segment'],
      dtype='object')
```

In [8]:
```python
# Standardization
X = data.drop('Customer_Segment', axis=1)
y = data['Customer_Segment']

scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
```

In [9]:
```
plt.figure(figsize=(6,4))
sns.countplot(x=y, palette="Set2")
plt.title("Distribution of Wine Types")
plt.xlabel("Wine Type")
plt.ylabel("Count")
plt.show
```

Out[9]:
```
<function matplotlib.pyplot.show(close=None, block=None)>
```

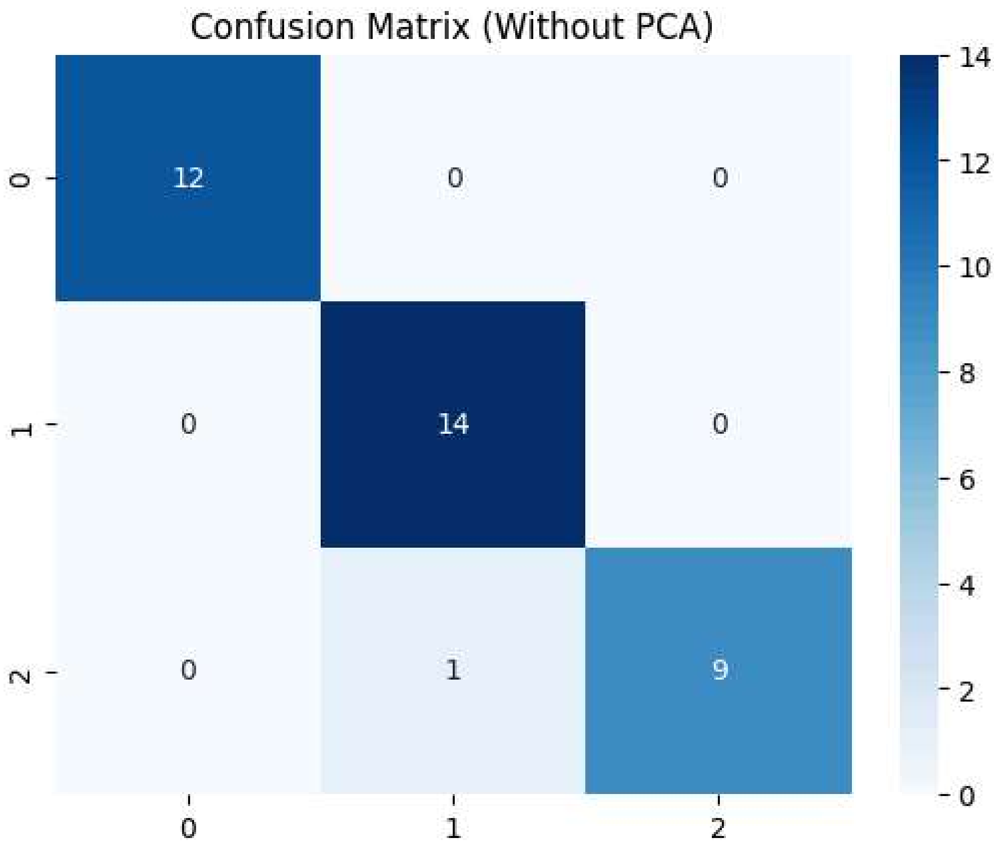



In [10]:
```
 # Step 5: Train-Test Split
 # ------------------------------------------------------------
X_train, X_test, y_train, y_test = train_test_split(
 X_scaled, y, test_size=0.2, random_state=42, stratify=y
 )
```

In [11]:
```
# Step 6: Model WITHOUT PCA
 # ------------------------------------------------------------
clf_orig = LogisticRegression(max_iter=500)
clf_orig.fit(X_train, y_train)
y_pred_orig = clf_orig.predict(X_test)
```

In [12]:
```
print("\n--- Model WITHOUT PCA ---")
print("Accuracy:", accuracy_score(y_test, y_pred_orig))
sns.heatmap(confusion_matrix(y_test, y_pred_orig), annot=True, fmt='d', cmap="Blues
plt.title("Confusion Matrix (Without PCA)")
plt.show()
```

```
--- Model WITHOUT PCA ---
Accuracy: 0.9722222222222222
```

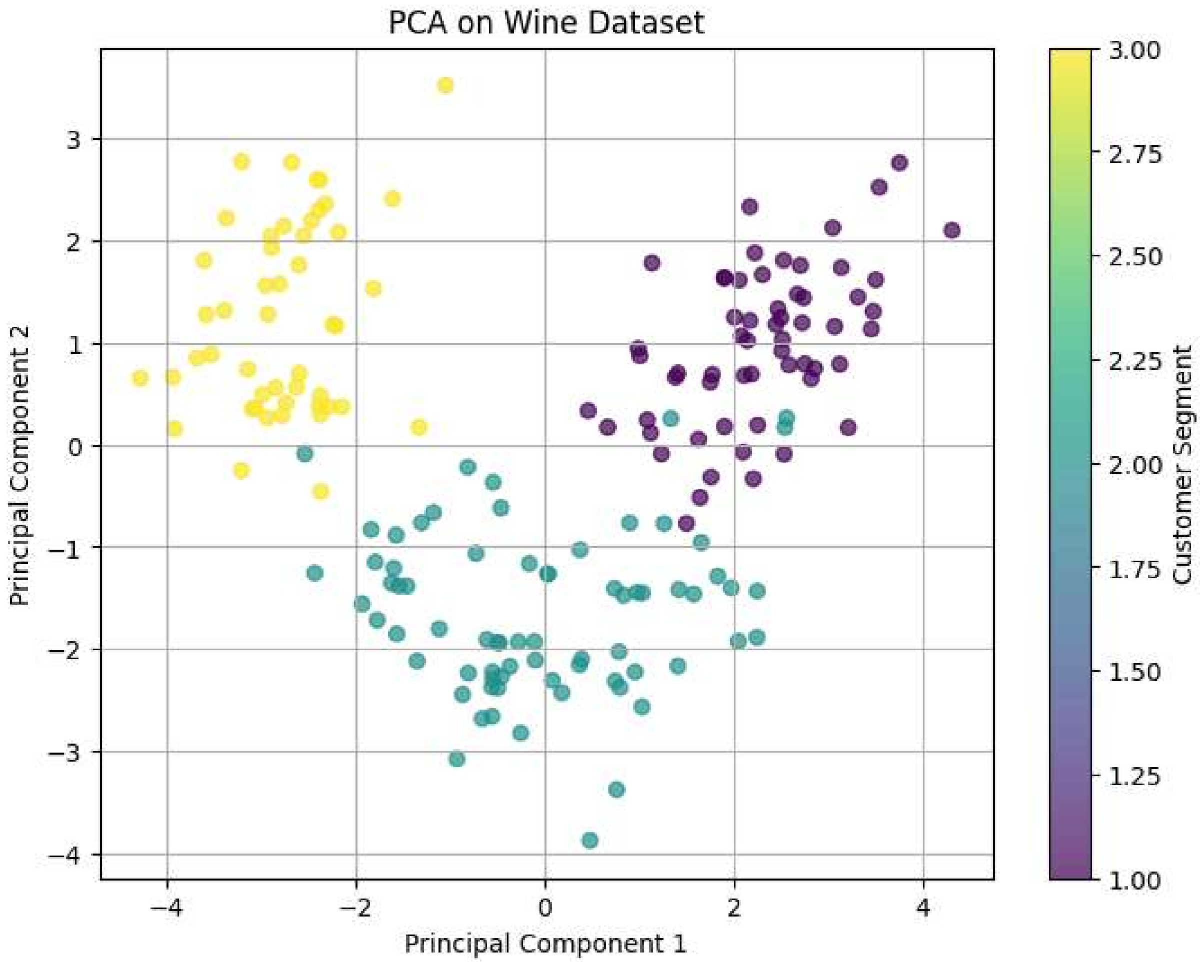



In [13]:
```
# Apply PCA
pca = PCA(n_components=2)
principal_components = pca.fit_transform(X_scaled)
```

In [14]:
```
principalDf = pd.DataFrame(data=principal_components,
                           columns=['Principal Component 1', 'Principal Component 2
finalDf = pd.concat([principalDf, y.reset_index(drop=True)], axis=1)
print(finalDf.head())
```

```
   Principal Component 1  Principal Component 2  Customer_Segment
0               3.316751               1.443463                 1
1               2.209465              -0.333393                 1
2               2.516740               1.031151                 1
3               3.757066               2.756372                 1
4               1.008908               0.869831                 1
```

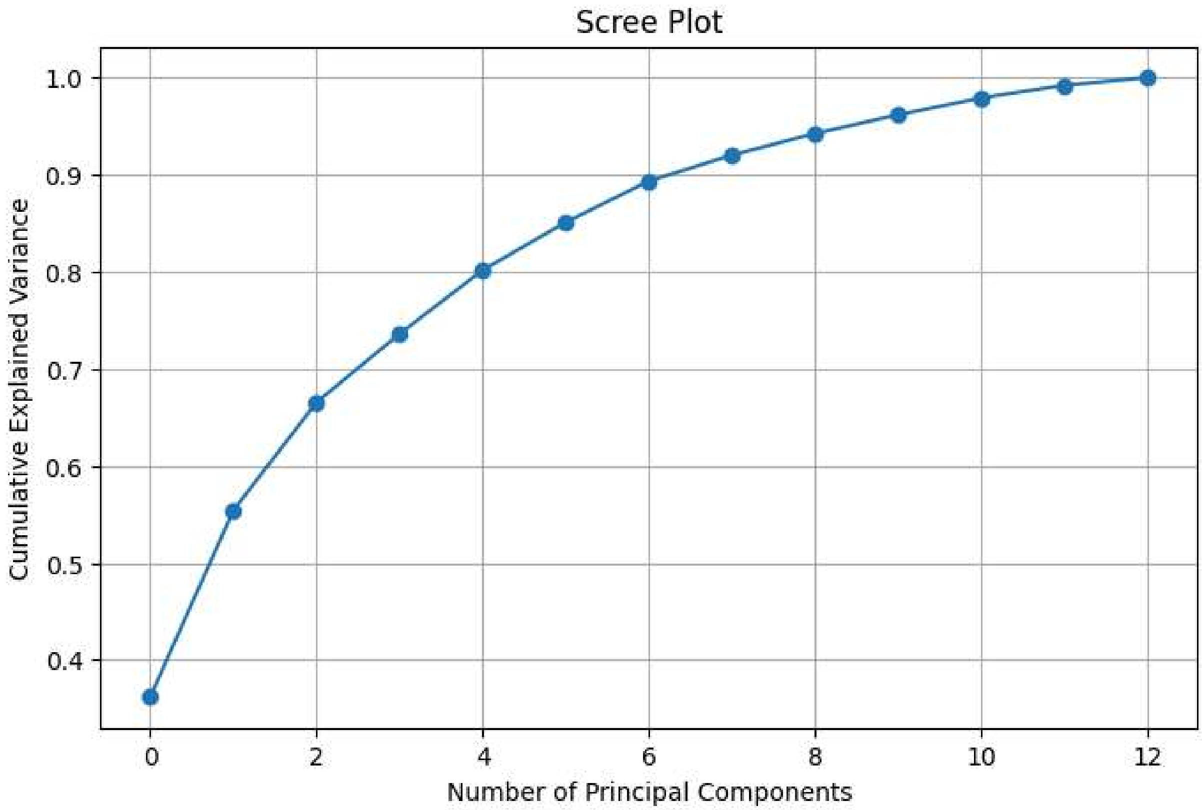
In [15]:
```
#Visualization
plt.figure(figsize=(8,6))
plt.scatter(finalDf['Principal Component 1'], finalDf['Principal Component 2'],
            c=finalDf['Customer_Segment'], cmap='viridis', alpha=0.7)
plt.xlabel('Principal Component 1')
plt.ylabel('Principal Component 2')
plt.title('PCA on Wine Dataset')
plt.colorbar(label='Customer Segment')
plt.grid()
plt.show()
```




In [16]:
```
# Variance
print("Explained variance ratio:", pca.explained_variance_ratio_)
print("Total variance explained by 2 PCs:", sum(pca.explained_variance_ratio_))
```

```
Explained variance ratio: [0.36198848 0.1920749 ]
Total variance explained by 2 PCs: 0.5540633835693527
```

In [17]:
```
pca_full = PCA().fit(X_scaled)
plt.figure(figsize=(8,5))
plt.plot(np.cumsum(pca_full.explained_variance_ratio_), marker='o')
plt.xlabel('Number of Principal Components')
plt.ylabel('Cumulative Explained Variance')
plt.title('Scree Plot')
plt.grid()
plt.show()
```

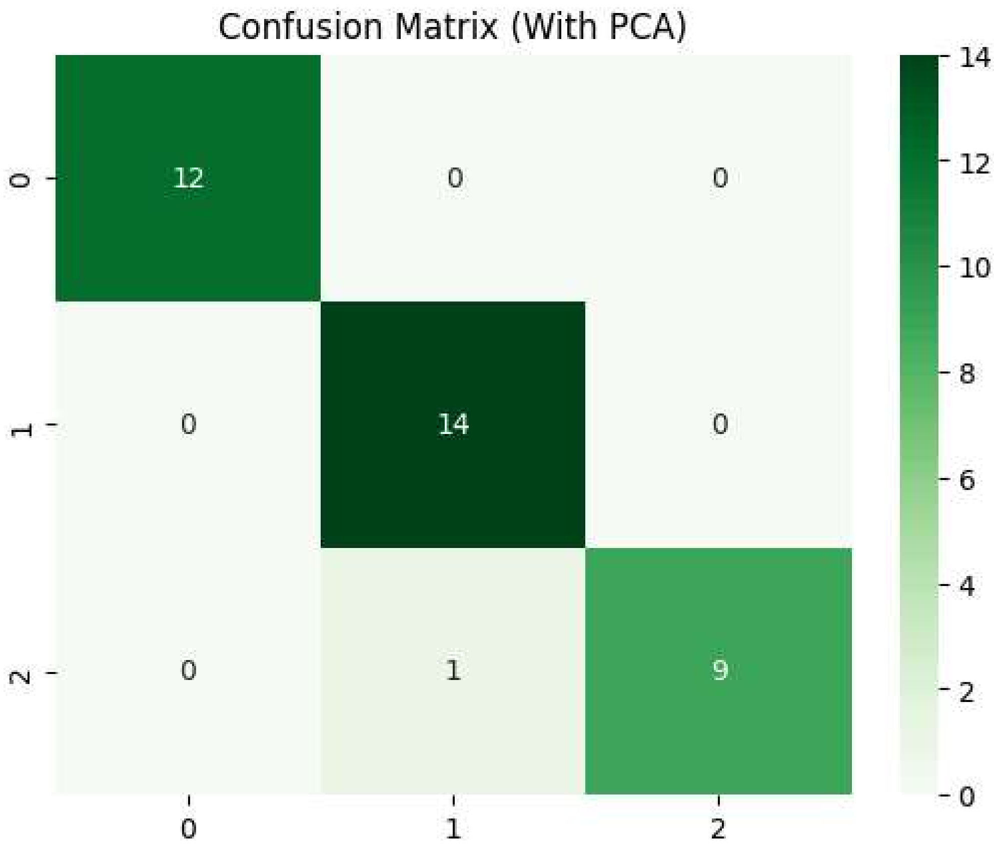



In [22]:
```
# Step 8: Model WITH PCA
Xp_train, Xp_test, yp_train, yp_test = train_test_split(
 principal_components, y, test_size=0.2, random_state=50, stratify=y
 )
```

In [23]:
```
clf_pca = LogisticRegression(max_iter=500)
clf_pca.fit(Xp_train, yp_train)
yp_pred = clf_pca.predict(Xp_test)
```

In [24]:
```
print("\n--- Model WITH PCA ---")
print("Accuracy:", accuracy_score(yp_test, yp_pred))
sns.heatmap(confusion_matrix(yp_test, yp_pred), annot=True, fmt='d', cmap="Greens")
plt.title("Confusion Matrix (With PCA)")
plt.show()
```

```
--- Model WITH PCA ---
Accuracy: 0.9722222222222222
```



Confusion Matrix (With PCA)
12
0
0
0
14
0
0
1
9
0
1
2
0
1
2
14
12
10
8
6
4
2
0